B B C LAKE ON MARS COULD IT HARBOUR ALIEN LIFE?





DAVID YARROW INTRODUCES THE NIKON FULL FRAME D850.

To launch the new Nikon D850, master wildlife photographer David Yarrow was given the creative freedom to capture the image of his lifetime, shot on the D850. Thanks to the powerful combination of the 45.7MP FX format back-side illuminated CMOS sensor and the speed of 9*fps shooting, he could tell a story like never before. With ISO 64 to 25600, 153-point AF, 8K time-lapse** and full frame 4K UHD video, now you too can capture your masterpiece. David is passionate about wildlife conservation, and is the affiliated photographer of the Tusk Trust Foundation. To find out more about the D850, and David's story, visit www.nikon.co.uk





A drug derived from the capsaicin in chilli peppers could help fight obesity →p22

WELCOME



I'm sure I'm not alone in saying that dinner time is often the highlight of my day. For me, tucking into a truly tasty meal is one of the greatest joys in life – right up there with meeting one of your all-time heroes, welcoming your first-born into the world, or watching Arsenal clinch the double in a close final game of the season.

So I pity our ancestors when I picture them existing on a diet of boiled turnips, gritty

pigeon innards and musty sea buckthorn. No fish and chips? No Thai red curry? No pizza? No thanks! Luckily for me, our diets have come a long way since the dark ages. But what are we going to be eating in the future? With natural resources being consumed at a rate never seen before, and the threat of climate change looming ever larger, it looks likely that we're all going to have to change our eating habits. But don't worry, we're not going to be consigned to living on food pills or tasteless techno gruel: science will come to the rescue. In this issue we look at the food we'll be eating in 10 years' time, and the innovative methods we'll use to grow it and cook it. Look forward to robot chefs, meal plans custom-matched to your genome, and breathtakingly beautiful 3D-printed desserts.

Also in this issue, we look at the psychology behind the growth of the Flat Earth movement (p58), meet the investigators using data from DNA ancestry tests to crack cold cases (p66), and peer inside the mind of the psychopaths hiding in plain sight (p74). Plus, we welcome new columnist Aleks Krotoski, presenter of BBC Radio 4's *Digital Human*. Turn to p26 to read about how she used simple techniques to overcome her crippling fear of public speaking.

Daniel Bennett

Daniel Bennett, Editor

IN THIS ISSUE



Psychologist and writer
Nicola reveals why there
are more psychopaths
around than you think
(and why that's probably
okay). → p74



STUART FARRIMOND

Doctor turned writer and TV

presenter Stuart looks into
the future of food – from
edible spray paints to
genetically engineered
superfoods. → p40



MOYA SARNER

Writer Moya spent some time hanging out with Flat Earthers to find out why they're so committed to a worldview that science rejected centuries ago. → p58

WHAT WE'VE FOUND OUT THIS MONTH



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Eye openerIncredible images from around the world.

10 **Reply**Your letters and emails.

13 Discoveries

This month's biggest science news. PLUS: What caused the summer heatwave?

26 Aleks Krotoski

How I overcame anxiety.

27 **Michael Mosley**Airborne pollution: the silent killer.

29 Innovations

The latest technology and gadget news. PLUS: Electric vehicles on test.

81 **Q&A**

Your science questions answered.

90 Out there

Science stuff to look forward to this month: books, exhibitions, days out and more.

96 Crossword

A grey matter tester in black and white.

98 **My life scientific**Ella Al-Shamahi on combining stand up

comedy and palaeoanthropology.

48 Subscribe Subscribe to *BBC Focus* today and save yourself 40 per cent!





FEATURES

What we'll eat in 2028

It's food, Jim, but not as we know it: how necessity and invention will combine to alter the food on our plates.

The seeds of change

Population growth and climate change present new challenges to farmers, but they're fighting back with technology.

The rise of Flat Earthers

Why do people believe in conspiracy theories that fly in the face of all the scientific evidence? Moya Sarner investigates...

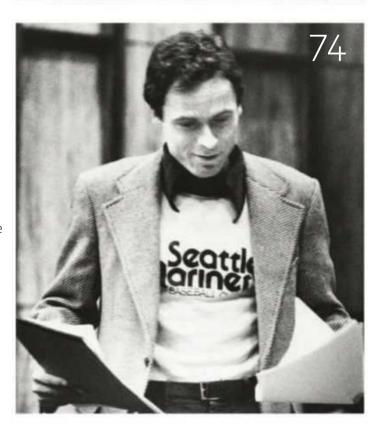
DNA ancestry kits caught a serial killer

How combining DNA evidence and genealogy is bringing killers to justice.

Inside the minds of everyday psychopaths

Not all psychopaths are killers: in fact, it's highly likely that one of them is your employer.





WANT MORE?

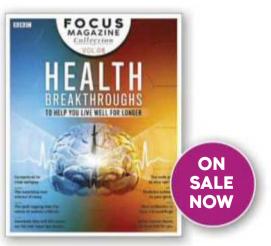
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MESSAGE OF THE MONTH

Live fast, die old

Michael Mosley's column (Summer, p27) sheds light on the benefits of 'daily fasting' and eating only during restricted daytime hours. Only a generation or two ago this was a normal way of consuming food, dictated by necessity and sometimes also by traditions and customs.

My grandparents, who were married in 1902, lived in a house without central heating and running water. To keep milk fresh, they lowered the closed milk container on a rope into the well to hang just above the water level. Their daily routine didn't begin with breakfast in bed—they had to fetch wood to light the stove, water for their morning cup of tea, and milk out of the well. Being devoted Eastern Orthodox Christians, they said their prayers every morning before they would eat or drink anything. Sometimes it was almost midday by the time they had their first meal, and they had their last between 6pm and 7pm, so their 'daily fast' was always about 15 or 16 hours. And they lived into their 90s.

Their children and grandchildren, however, enjoyed modern comforts, with food available around the clock and religion seen as old-fashioned. Obesity, heart disease and early death followed – four of my grandparents' sons died in their 50s and 60s, so did several grandsons. Their three daughters lived into their 80s, but so far no granddaughters have survived beyond their 70s.

My grandparents would have been horrified at the way we use food in the West nowadays, eating more than is needed for sustenance and throwing food away because we bought too much in the first place. Diets often encourage this prodigality while their effect is limited. We should rethink our attitude to food for the sake of both our own health and that of our environment. Elena Holden, Hampshire





Modern attitudes to food could be damaging our health and the environment, says Elena Holden

Born to sin?

I have recently been enjoying your podcast after seeing an advert for it in a recent issue. I listened to the episode about sin with Jack Lewis (from 27 June), and it made me wonder whether certain people are more predisposed to 'sin' in certain ways compared to other people?

Say, for example, whether some people or families are more inclined to gluttony or envy than others

– and whether this is because of their brain structure or a product of their upbringing – or whether we are all equally likely to experience all types of sin? Do you know if anyone has done any

research into this?

I am glad I have finally discovered your podcast because it

can keep me company on the walk to and from the train station! April Hayes, via email

Glad you like the podcast! We've forwarded your question on to Jack Lewis.

- Daniel Bennett, editor

Beds over bombs

Having finally roused myself from my lethargy to comment on

your excellent article
about the virtues of
laziness (Summer,
p39), I feel that the
greatest advantage
of all was
overlooked: how
much better the
world would be if
we had all greeted
demagogues and
warmongers with a
yawn and a "Yeah,

whatever... maybe next year for your war?"

Hitler and the rest of them could have fought among themselves while the rest of us looked idly on. Surely the greatest evolutionary advantage of all? Now I really must go and have a lie down.

Alan Blackwood, Tameside

Morning melancholy

Regarding your story on 'night owls' being more prone to depression (Summer, p21), is it possibly because we owls spend a good deal of our lives jetlagged and sleep deprived?

School and work hours in the developed world are geared towards larks, so we mostly find waking up hard, then spend the first two or three hours stumbling about half awake. Think auto-hangover every weekday. Then there's the difficulty getting to sleep early enough... it's enough to make anyone depressed! Hilary Gee, Grange-over-Sands

Email - not so eco-friendly?

In your June issue (p83) there was an interesting discussion of the carbon footprint of an email. It suggested that the environmental impact effect of sending an email is quite small, but I would challenge this finding.

While an individual email adds virtually nothing to the CO_2 in the world, this calculation does not take into account the fact that most of the world's computers are phantom users of electricity. Running 24/7, they are continually consuming electricity – not just when we get our emails. This would be akin to leaving our car idling in the driveway, waiting for the next trip to the grocery store.

We don't just boot up our PCs, download our emails and then shut them off. Therefore, sending and receiving emails consumes far more than the 4g each that is quoted. Whit Strong, Ottawa, Canada

That's a valid point, but since we use computers for other things, too, we can't blame all of that electricity on email. A true calculation would have to determine what proportion of our computer time is spent on email vs gaming vs spreadsheets and so on and divide up the idle electricity pro rata. What's more, most computers enter sleep mode if they're left idle, and this typically consumes only 4W of electricity. If your computer spends 20 hours a day in sleep mode, this is equivalent to sending an extra seven emails. – Luis Villazon,

BBC Focus contributor

Leaving computers switched on is bad for the environment, argues Whit Strong



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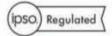
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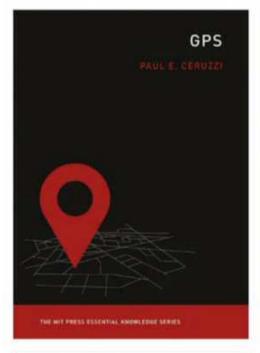
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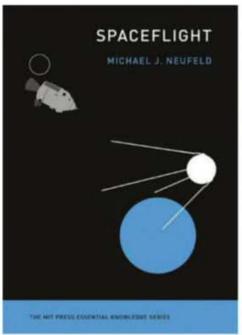
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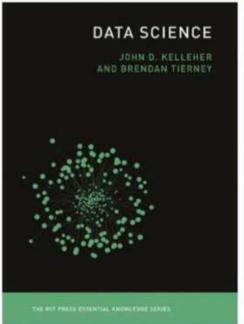
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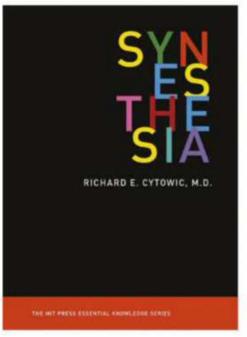
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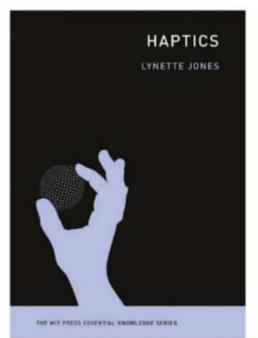
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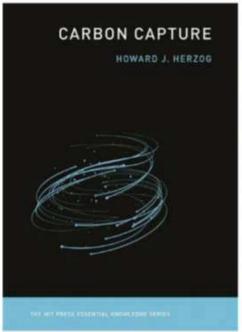


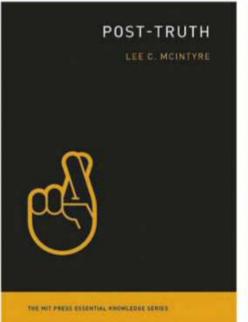


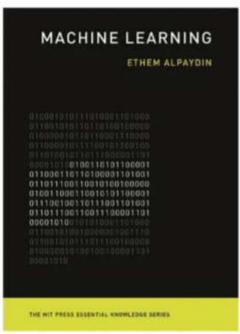












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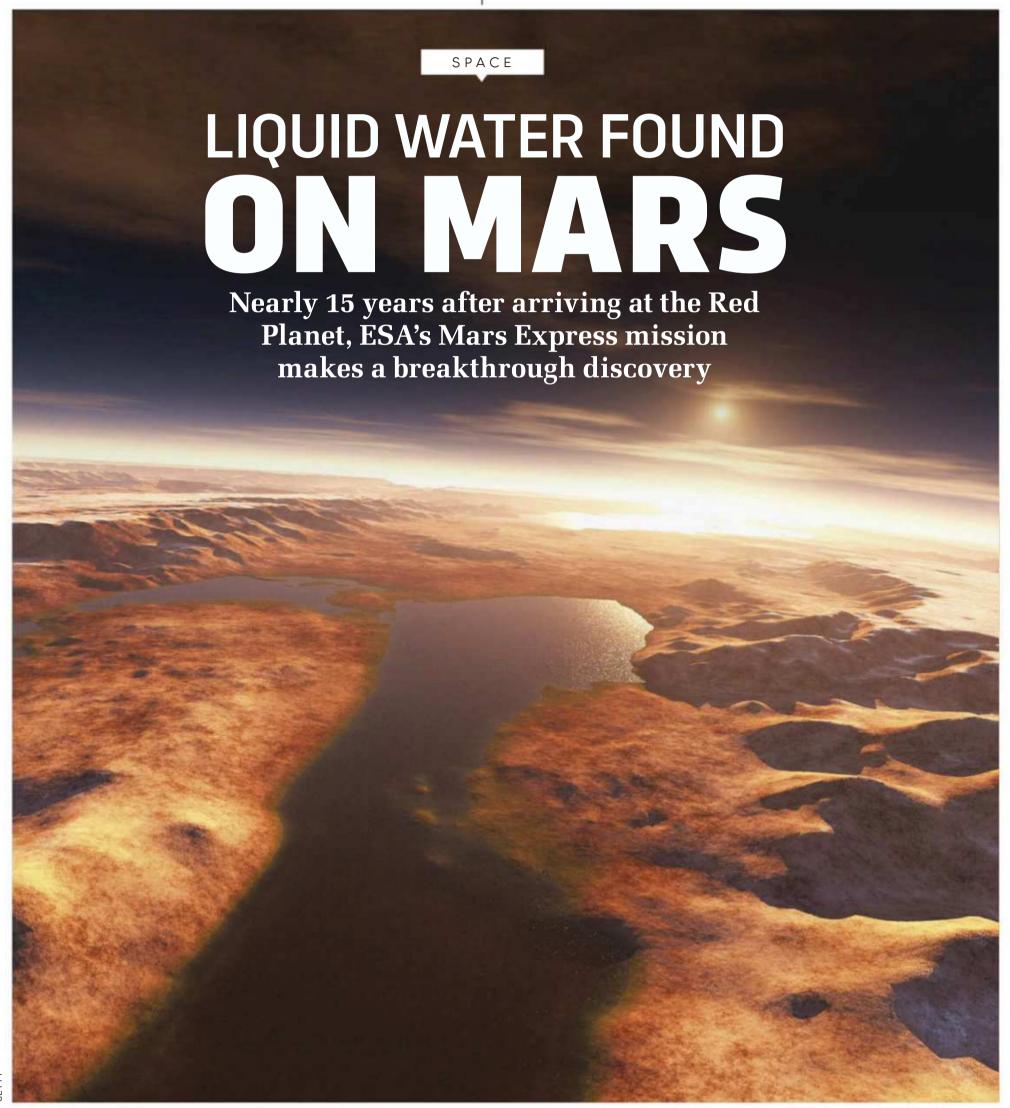
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DISCOVERIES

DISPATCHES FROM THE CUTTING EDGE

SEPTEMBER 2018 EDITED BY JASON GOODYER



/TTJ



At the end of July, scientists from the European Space Agency (ESA) announced what's arguably one of the biggest scientific breakthroughs of 2018 so far: there *is* liquid water on Mars. The discovery of an underwater lake below a glacier in Mars's south polar region was made using the MARSIS (Mars Advanced Radar for Subsurface and Ionosphere Sounding) instrument on ESA's Mars Express probe, which has been in orbit around the Red Planet since December 2003.

While the surface of Mars is far too cold for water to exist in liquid form, the covering of ice at the poles, which can be up to 2km thick, acts like an igloo, trapping what little heat Mars emits due to the decay of radioactive elements within its core. If the water in question is also highly salty, as it's believed to be, it could therefore persist in liquid form, as salty water has a lower freezing point.

Mars Express project scientist Dmitri Titov, who's been involved in the mission since its earliest days, was upbeat about the discovery. "MARSIS has told us lots of other interesting things," he said. "Its subsurface sounding of the entire planet has revealed the many layers below the surface, and its radar is also very efficient at

"ONE OF THE
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EXPERT COMMENT

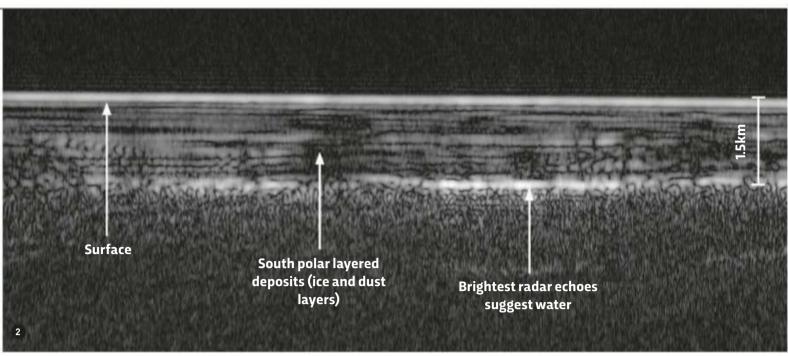
Prof Lewis Dartnell

Astrobiologist and senior editor of the journal Astrobiology

"This discovery of a lake of liquid water underneath the south polar ice cap on Mars is very exciting for astrobiology and the search for life beyond Earth. Liquid water is one of the major prerequisites for life, and similar environments on Earth, such as Lake Vostok, sealed deep beneath the Antarctic ice sheet, provide analogues for what sort of microbial life we might hope to find here on Mars.

"But this subsurface lakewater on Mars would be an extremely challenging environment for life to survive in. The water, although liquid, is still punishingly frigid at around -70°C, and is probably also very salty to keep it liquid at such low temperatures. The lake is also 1.5km beneath hard-frozen ice, and so would be difficult to reach with robotic probes. But this is certainly a exciting potential habitat for extraterrestrial life that we'd love to try to explore."







ESA's Mars Express probe

Radar signals sent out by the MARSIS instrument can be used to build an image of the Red Planet's interior. Here, the brightest regions suggest the presence of water

3 NASA's Mars
InSight lander is
due to arrive at the
Red Planet later
this year, and
should tell us even
more about the
planet's interior

sounding the ionosphere [upper atmosphere], so it's really a very multidisciplinary operation. But one of the primary goals of the mission, like a torch on the far horizon, was always to discover water."

Scientists have known for a long time that there was water on the Martian surface in the distant past, due to the erosion patterns in the rock and the existence of hydrated materials. The presence of water ice today was confirmed for sure 10 years ago by NASA's Phoenix lander, but this is the first time that liquid water has been discovered there.

The discovery was made possible by what was effectively a firmware upgrade to MARSIS, so that instead of studying the whole planetary surface in standard resolution, it sent back high-resolution data from a specific area. To do this, the team had to bypass some of the onboard data processing, which as Titov explains "was doing some kind of averaging and calculations onboard. But now they said no, let's just download all of the data and do all the processing here on the ground."

IS THERE LIFE ON MARS?

The underwater lake found by MARSIS is similar in many ways to Lake Vostok, the lake that in 1973

was discovered lying under four kilometres of Antarctic ice here on Earth. Given that there are widely believed to be unknown microbes dwelling in Lake Vostok, what does the MARSIS discovery say about the prospects for finding life on Mars?

"I think that yes, now we have some potential for Martian life," said Titov. "Simply because water is there and water is one of the major ingredients. It's also important that this water is hidden under a 1.5 to 2km layer of ice, which protects it from the intensive UV radiation from the Sun. But getting there and drilling through the ice is a huge challenge, so it will be some time, possibly decades, before we know for sure."

In the meantime, the MARSIS instrument will continue to look for more subsurface pockets of water. But the discovery of just one has clearly made Titov and his team extremely happy.

"For us, this discovery demonstrates that despite the mission being quite old now, despite there being new missions there, it still it has the potential for new discoveries, for collecting new data," he told us. "So it's very good news for the Mars Express team."

The man who gets to say 'I told you so'

Mars Express's discovery is bound to have made the Planetary Science Institute's Simon Clifford smile – because he predicted the existence of such lakes back in 1987

"Back in the 80s, we knew liquid water existed below Earth's polar ice sheets," he told *BBC Focus*. "On Mars, we knew the surface temperature, we had some idea of the thickness of the polar caps, and we knew that Mars, like Earth, generates internal heat. So it was just a case of putting all those elements together. Of course, 30 years ago people weren't yet used to thinking of Mars as a water-rich planet, so there was some resistance to the idea at first. But thanks to MARSIS, we now have very persuasive evidence that such lakes do indeed exist."

ZOOLOGY

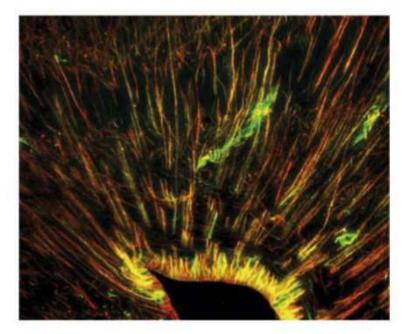
GECKOS THAT CAN REGENERATE DAMAGED PARTS OF THEIR BRAINS COULD HELP HEAL HUMANS

Leopard geckos are well known for being able to shed their tail when threatened by predators, only to grow it back again. But now researchers at the University of Guelph, Canada have found that they may also be able to regenerate parts of their brains. The finding could lead to treatments for replacing human brain cells that have been lost or damaged due to injury, ageing or disease, the researchers say.

The team discovered that stem cells frequently produce new brain cells in the medial cortex of the geckos, a part of the brain that is responsible for social cognition and behaviour. This part of the lizard's brain has a well-studied counterpart in the human brain – the hippocampus.

"The brain is a complex organ and there are so few good treatments for brain injury, so this is a very exciting area of research," said Prof Matthew Vickaryous, who took part in the research. "The findings indicate that gecko brains are constantly renewing brain cells, something humans are notoriously bad at doing."

To make the discovery, the team injected the lizards with a chemical label that latched onto the DNA of newly formed cells, allowing them to see where they first arose, how they moved, and what type of cell they ultimately became.

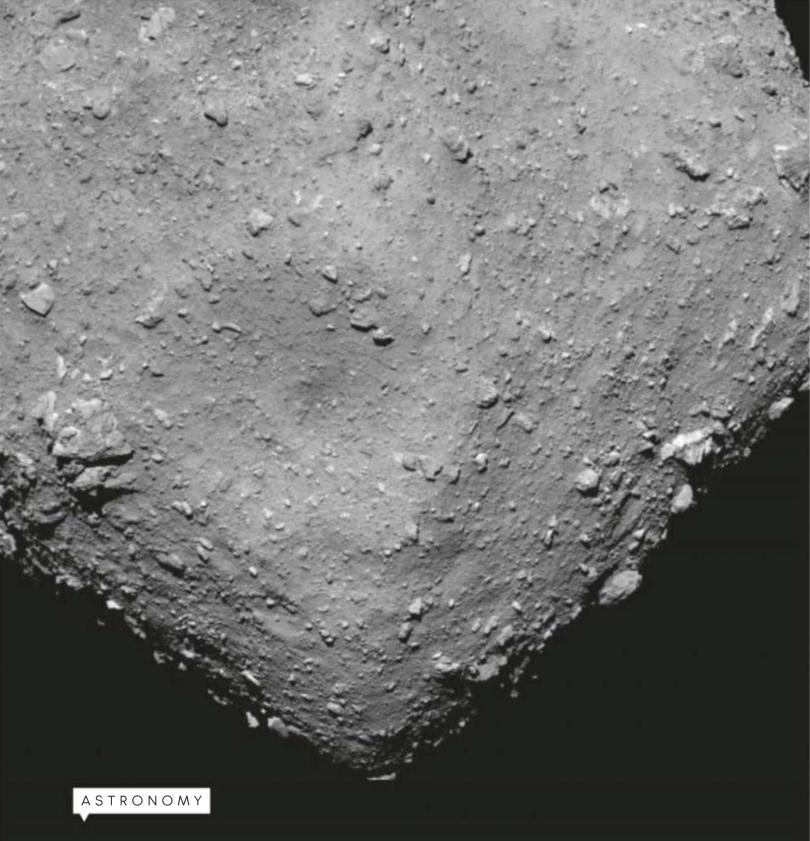


"The next step in this area of research is to determine why some species, like geckos, can replace brain cells, while other species, like humans, cannot," said lead researcher Rebecca McDonald, a student of veterinary medicine who specialises in healing. "Recently, there's been a lot of new information coming out about the brain's ability to produce new cells, something that was long thought to be impossible. This is definitely an area of research that has potential to change the way we treat brain injuries."



ABOVE: Stem cells in a gecko's medial cortex allow the animal to regenerate its brain cells

LEFT: The leopard gecko is native to Asia. Unlike many gecko species, it cannot run up vertical walls



JAPANESE SPACE PROBE TAKES STUNNING SNAPS OF ASTEROID

Well, this rocks! The Japan Aerospace Exploration Agency's (JAXA) Hayabusa2 probe has snapped this stunning shot of asteroid 162173 Ryugu from just 6km above the asteroid's surface – an important milestone in the probe's overall mission.

As outlined in last month's *BBC Focus* (August, p40), Hayabusa2's eventual goal is to bring back rock samples from Ryugu, as its predecessor the Hayabusa probe did from the Itokawa asteroid in 2010. Once returned to Earth, these samples will be studied by JAXA scientists with a view to discovering more about both asteroids' physical make-up – knowledge that would be vital should humankind need to deflect any asteroid

threatening to collide with our planet in the future – and their chemistry.

Asteroids are believed to have delivered many of the chemicals needed for life to form, such as amino acids and the nucleotides that make up our DNA, to the young Earth. So far, however, our knowledge of the chemistry of an asteroid's surface is largely derived from studying meteorites – asteroid fragments which have landed upon the Earth, which makes it difficult to determine if they have been contaminated with material after crashing down to the surface. Studying asteroid samples straight from the source, such as those Hayabusa2 will bring back, will give scientists a much clearer picture.

IN NUMBERS

12

The number of previously undiscovered moons found in orbit around Jupiter. This brings the total number of moons around the gas giant to 79 – the most of any planet in the Solar System.

42,000 YEARS

The age of nematode worms that were successfully revived recently, after they were discovered lying frozen in Siberian permafrost.

5

The percentage drop in end-of-term exam performance for students who were allowed access to a smartphone or tablet for non-academic purposes in lectures, according to a study at Rutgers University.

ABOVE: Fear of heights is common, and can impact on people's lives if it develops into a phobia

Could virtual reality be useful in treating anxiety disorders? Psychologists led by Prof Daniel Freeman of Oxford University are using VR to help people overcome their fear of heights

What causes a fear of heights?

Some people really overestimate the danger: they think they're going to fall, throw themselves off ('the call of the void') or that a building might collapse. That causes anxiety, it causes people to avoid heights and it can impact on day-to-day life: they can't walk or drive across bridges, or go to meetings high-up in office blocks. About 1 in 20 people have it at the level of phobia, when you've had it for at least six months. Vertigo is something different, a balance issue.

Why treat it with virtual reality?

There are some good psychological treatments for mental health problems and if you see a skilled therapist, you can do really well. But it can be hard to find a therapist, so we're trying to help people via automated virtual reality. The fear of heights programme was our first test.

What did the treatment involve?

People came to the offices of [university spinout company] Oxford VR. We screened them for at least a moderate fear of heights and had 49 randomised to the VR treatment and 51 to the control condition. They received the treatment,

which consisted of about five VR sessions of 30 minutes each, over the course of two weeks.

In the VR package we've been using, you meet the therapist, who's called Nick, in a virtual office. She explains what causes a fear of heights and how to overcome it, then takes you into the atrium of an office block and asks, "Which of the 10 floors do you want to start off with?". You go up to whichever floor you selected and carry out a range of tasks: it might be just standing by the edge, rescuing a cat from a tree, or traversing a rickety walkway. In this way you can learn that your fears are inaccurate and misguiding your behaviour, because actually nothing bad happens.

How did you measure improvement?

It's a series of questions on clinical assessments – all these questionnaires are validated against performance at real heights. People's fears came down on average by two-thirds, and 69 per cent no longer met the trial entry criteria. It's not a direct comparison, but compared to other trials that use face-to-face therapy, the effects are almost double. I was surprised the results were even better than expected. There's no reason why it shouldn't help people with a milder fear of heights.



BELOW: Oxford University's virtual reality application lets people carry out a range of tasks at different heights, without any risk One of the beautiful things about VR is you know it's not real, so you try things you would never do. Then when you come up against much more mundane heights in day-to-day life, you have the confidence that you can deal with it.

When will VR treatments be available?

Over the next couple of months, we're piloting

this treatment in NHS
psychological services,
putting the VR kit into
clinics. In future years,
people could do the
treatments at home, but at
the moment they don't have
the equipment.

Oxford VR is employing people from the games industry to make these sorts of treatments much more fun and engaging. We think we can learn a lot from the computer games industry in terms of making mental health treatment much more appealing to people.



Virtual reality enables people to experience a simulated problematic situation without any actual, real world risk. For this reason many mental health experts have been exploring its therapeutic potential. Post-traumatic stress disorder, fear of flying, arachnophobia and persecutory delusions are just some of the areas where VR has shown promise.



RURAL DWELLERS

Mental decline occurs much more slowly among those living in villages than among urban dwellers, a 10-year study carried out in Barcelona has found. Reduced stress, lower pollution levels and more active lifestyles are all believed to be factors.

LYING POLYGLOTS

Multilingual Pinocchios, rejoice! The University of Würzburg has found that we feel emotions less strongly in a second language, so the stress that is associated with lying is reduced, making it easier for us to tell those fibs.

GOOD MONTH

BAD MONTH

SPORTS FANS

As any supporter of a less successful team can attest, being a sports fan can be hard work at times. Now, a study carried out using a happiness monitoring app by researchers at the University of Sussex has found that the despair felt by sports fans when their team loses is twice as strong as the elation felt when their teams win.

BUSINESSMEN

Time to loosen up office dress codes? German researchers have found that wearing a tight necktie can reduce blood flow to the brain by as much as 7.5 per cent. The restriction could prove problematic for those with high blood pressure or circulation issues.



ZOOLOGY

TREE SHREWS' TASTE FOR SPICY FOODS EXPLAINED

Many of us like nothing more than tucking into a fiery chicken madras or lamb bhuna, but the majority of other animals do their best to avoid hot, spicy foods such as chillies – which is precisely why such plants evolved to be hot and spicy in the first place. However, we're not entirely alone: tree shrews (*Tupaia belangeri chinensis*) will also happily chow down on chilli peppers when given the chance. Now, an analysis of their genome by researchers at China's Kunming Institute of Zoology has explained the secret of their tolerance.

Spicy foods derive most of their heat from a chemical called capsaicin. When eaten, capsaicin triggers the activation of TRPV1 – a receptor channel found on the surface of painsensitive cells in the tongue and elsewhere.

TRPV1's regular job is to alert animals to the presence of potentially harmful heat, which is why we experience a burning sensation and often start to perspire when eating spicy foods.

The team began their study of the tree shrew after they were shocked to see captive animals happily munching on chilli peppers. They discovered that a single mutation in the shrews' TRPV1 gene decreases their receptors' sensitivity to capsaicin. While chilli peppers do not grow within the shrews' natural range, a plant called *Piper boehmeriaefolium*, which contains a substance similar to capsaicin called Cap2, does. It's therefore believed that shrews with the mutation in question gained an evolutionary advantage over those without, thanks to their expanded diet.



THEY DID WHAT?!

YOUNG MEN TURNED INTO VIRTUAL EINSTEINS

What did they do?

Researchers at the University of Barcelona invited 30 men aged 18-30 to take part in a half-hour VR experience, in which half saw themselves in a generic male face and body, and half in the face and body of Albert Einstein.

Before and after the VR experience, they took tests to measure self-esteem, cognitive function, and their views of the elderly.

What did they find?

Subjects who had exhibited low self-esteem at the start and who 'played' Einstein on the VR platform demonstrated higher self-esteem and better cognitive function in the following tests. Their views of the elderly also became more positive in the second round of tests.

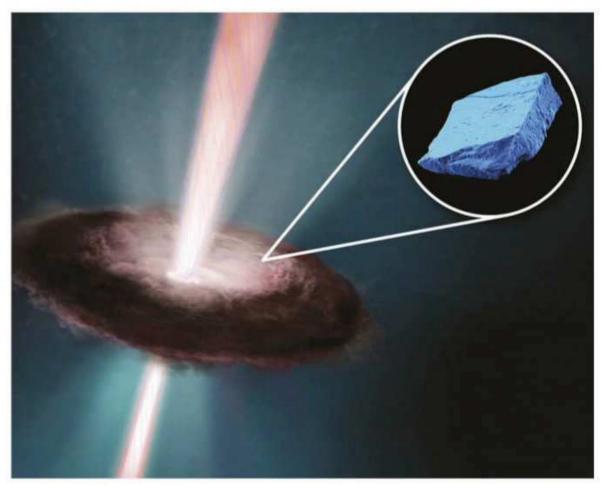
Why did they do that?

The researchers wanted to study the effects of role-playing different characters in VR. In this instance, they wanted to know if playing a highly respected individual such as Einstein would boost self-esteem and cognitive function – as it seemed to. If the results can be replicated with a larger group of subjects, the findings could have both educational and therapeutic applications.



ASTRONOMY

CRYSTALS TRAPPED IN METEORITES REVEAL THE SUN'S VIOLENT PAST



4.5-billion-year-old hibonite crystals (inset) have shed new light on the earliest days of the Solar System (main image)

The Sun burst into being 4.6 billion years ago, around 50 million years before the Earth formed. This makes studying its early days incredibly difficult, as physical material remaining from this period is scarce. Now, a team from the University of Chicago has found crystals more than 4.5 billion years old buried deep within meteorites that indicate the Sun had a tumultuous early life.

Prior to the formation of the planets, the Solar System consisted of the Sun surrounded by a massive protoplanetary disc of hot gas and dust that spiralled around it. As this gas and dust cooled down it coalesced into minerals, including the blue hibonite crystals found embedded in meteorites that have landed on Earth.

Upon examining the crystals using a mass spectrometer, the researchers

were able to determine that they contained traces of helium and neon, which the team believes would have been created when high energy protons ejected from the young Sun struck the calcium and aluminium atoms within the crystals.

"In addition to finally finding clear evidence in meteorites that disc materials were directly irradiated, our new results indicate that the Solar System's oldest materials experienced a phase of irradiation that younger materials avoided," said lead researcher Levke Kööp.

"We think this means that a major change occurred in the nascent Solar System after the hibonites had formed," he continued. "Perhaps the Sun's activity decreased, or maybe later-formed materials were unable to travel to the disc regions in which irradiation was possible."

TRENDING

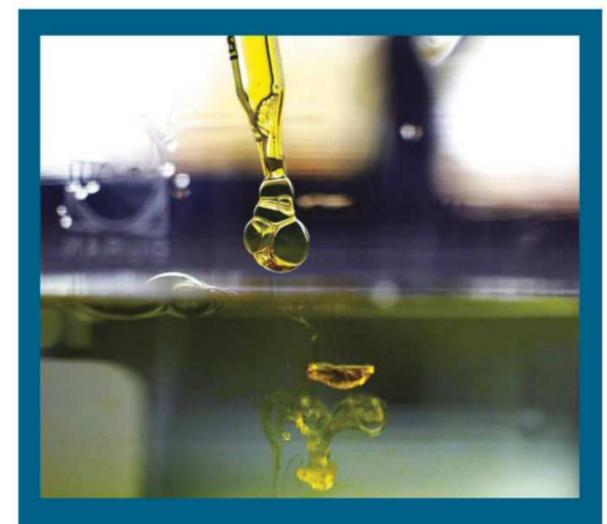
Your guide to the hottest topics in the world right now

#OBESITY

CAN'T LOSE WEIGHT? BLAME YOUR BACTERIA
It's well established that diet and exercise are key to losing weight, but gut bacteria may also play an important role, a study at Mayo Clinic in the US has found. A preliminary trial involving 26 participants enrolled in the clinic's obesity treatment scheme has found marked, consistent differences between the gut bacteria of individuals who lost weight and those who didn't.

ANTI-OBESITY DRUG DERIVED FROM CHILLI
A drug based on capsaicin, the compound
that gives chillies their spicy burn, has
triggered long-term weight loss in mice eating
a high fat diet, a study at the University of
Wyoming has found. When fed Metabocin, a
drug designed to slowly release capsaicin
throughout the day, mice burned white fat
cells rather than storing them, resulting in
weight loss and improved metabolic health.





#CANNABINOIDS

CANNABIS VS CANCER

Cannabidiol, or CBD, one of the main components of the cannabis plant, may help to extend the lives of pancreatic cancer patients that are undergoing chemotherapy, a study at Queen Mary University has found. Patients treated with the drug lived up to three times longer than those who followed more conventional treatments. The drug seems to block the action of a protein called GPR55, a major driver of many types of pancreatic cancer, the researchers say.

THC EASES AGITATION IN ALZHEIMER'S

One of the most distressing symptoms felt by Alzheimer's patients is the agitation as a result of confusion and disorientation. Now, researchers at the University of Toronto have found that nabilone, a synthetic drug similar to THC – the psychoactive compound found in cannabis – significantly improved feelings of agitation in 39 dementia patients over a six-week trial.

#PLASTIC

CRABS TO THE RESCUE

A team of researchers at the Georgia Institute of Technology have created a biodegradable plastic substitute using crab shells and tree fibres. The material was made by spraying alternate layers of chitin – a substance found in the exoskeletons of arthropods such as crabs and lobsters – and cellulose from tree fibres onto a surface. The substance resembles the plastic film that is often used to keep food fresh.

PLASTICS RELEASE GREENHOUSE GASES

Many common plastics release the powerful greenhouse gases methane and ethylene when exposed to sunlight, researchers at the University of Hawaii have found. They tested polycarbonate, acrylic, polypropylene, polystyrene and polyethylene – all materials used to make food wrappings, textiles and various plastic goods. Polyethylene, the plastic used in shopping bags, was found to be the biggest emitter of both gases.





#ENVIRONMENT

EARTH AT RISK OF REACHING 'HOTHOUSE' STATE
Researchers in Stockholm have published a
study showing that there is a risk of the Earth
entering a 'hothouse' state, even if
internationally agreed carbon emission targets
are met. In this state, the long-term climate could
stabilise at up to 5°C higher than pre-industrial
temperatures, with sea levels rising up to 60m
higher than today. These extreme changes are
due to environmental feedback loops such as
permafrost thaw, forest dieback and the
increasing loss of methane from ocean floors all
combining together, say the researchers.

'EARTH OVERSHOOT DAY' EARLIER THAN EVER
Earth Overshoot Day, the point in the year at
which the human race has consumed more
natural resources than the Earth is capable of
providing in 12 months, fell on 1 August this
year – the earliest date ever. According to
calculations by the Global Footprint Network, a
California-based think tank whose members
include the World Wildlife Federation, we are
using 1.7 Earths' worth of resources each year.
We first started overshooting in 1970, but the
effect has become progressively more
pronounced as time has gone by.



CLIMATE

WHAT HAS BEEN CAUSING 2018'S SUMMER HEATWAVE?

This summer has seen extreme weather right across the Northern Hemisphere, seemingly far beyond what has been seen in previous years. Widespread heatwaves have been observed on every continent, with weather records being broken left, right and centre. On 27 June, Oman reported a night-time temperature that never dropped below 42.6°C, a world record for the highest minimum temperature within a 24-hour period. Across the Red Sea, in the Sahara Desert, a new continental record maximum daytime temperature of 51.3°C was observed. Elsewhere on the planet, local temperature records have been broken in regions as diverse as the Arctic Circle, the US, Japan, Greece and the UK.

In many places the heat has been made worse by a lack of rain, which, if present, takes some of the energy from the Sun in the form of evaporation, thereby leaving less of the 'felt heat' in the surrounding area (a form of heat meteorologists call latent heat.). Satellite images of Great Britain show a clear and striking browning of the entire country for this summer compared with last, and hosepipe bans have been put in place in some counties to conserve water. Inevitably, hand-in-hand with hot, dry conditions come wildfires, and much of the hemisphere experienced widespread loss of forests, other vegetation, and human lives. Nowhere more so than Greece, where wildfires were visible from space, with strong winds compounding the outbreak, spreading the fires faster and dispersing the ash to the

surrounding regions, leading to Hollywoodstyle apocalyptic scenes of raging fires and ash-covered streets below an ominous red sky.

But in this world tainted by human-induced climate change, are these extraordinary weather events really a surprise? Some caution is required here, because while it's true that Earth's land has warmed by 1.6°C since pre-industrial times, climate and weather patterns other than

global warming can play critical roles in all types of extreme weather, including those seen this summer.

El Niño, a well-known global climate pattern that's associated with central Pacific ocean temperatures, causes even warmer heatwaves, and indeed led to 2016 being the warmest year on record. But this summer El Niño has been in a neutral phase, meaning that the widespread extreme heat occurred *without* the help of this natural mode of variability – making the heat and wildfires even more extraordinary.

Another factor in climate variability is the jet stream, which is responsible for extreme weather in the midlatitudes. The high-intensity winds of the jet stream circumnavigate the globe at around 10km above sea level and facilitate the movement of atmospheric waves, similar to the waves we observe on the beach but far larger in scale. Much like waves on a beach, these atmospheric waves can break, which is what we saw over northern Europe and Japan, creating weather patterns known as atmospheric blocks - regions of high pressure. But the European blocking this summer was special: relentlessly static, and almost as if it was nailed in place over Scandinavia. The consequences? A complete blocking of any cooler and unstable weather coming from the west, along with the creation of cloudfree regions over northern Europe and the UK, leaving the land at the mercy of direct sunlight.

When it comes to these climate patterns, it's often about what side of the jet stream you are on, so while the UK has been experiencing months of sought-after beach weather, Iceland for instance has been experiencing a dreary, wet couple of months. Understanding how climate change may alter the exact position of these patterns is therefore of high priority, but also proving to be particularly problematic. The consensus is that summer blocking conditions are unlikely to increase in duration, and indeed may decrease at low northern latitudes, as the blocking systems migrate polewards due to climate change.

The future may have a whole bunch of uncertain circulation patterns in stores for us, but you can be sure that these patterns will be superimposed on a background of much warmer air, making it extremely likely that heat waves and wildfires like this year will become the norm in the decades ahead. Indeed, if we don't act to stabilise our climate now, a typical weather report in 50 years' time may read, 'Conditions this year are relatively cool, with temperatures and wildfires akin to those of 2018'. Let's not wait to see what an extreme summer looks like in that world.





Dann Mitchell is a climate scientist based at the University of Bristol.

PORTRAIT: KATE COPELAND ILLUSTRATION: LUKE BROOKES

HOW I CONQUERED MY ANXIETY





Aleks Krotoski is a social psychologist, broadcaster and journalist. She presents BBC Radio 4's *Digital Human*.

eaver Creek, Colorado. It's a sweltering July day and I'm at an invite-only gathering of polymaths and dignitaries. I'm being introduced to this audience of extraordinary people as the next stimulating speaker. I hate this moment. I can hear the anticipation in the air; I can see their eyes shining with expectation. Soon I'll have to walk out, alone and vulnerable, to educate, enlighten and entertain. I feel confident with the education and enlightenment; I know I know my stuff. But the last, I fear, eludes me. I have flashbacks of misjudged, overly academic talks I've presented to silent rooms of people, their faces blue with the shine of their digital devices as they try to escape the drone of my words. Maybe that's a false memory, but it's the story that I tell myself about what happened. So it doesn't matter if it's true or not.

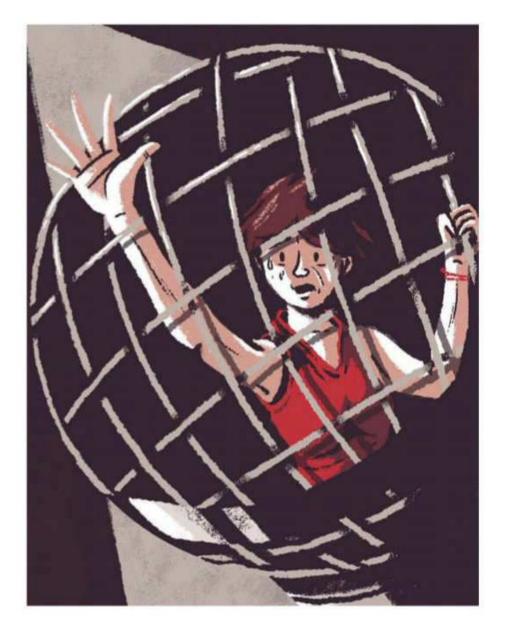
Public speaking sends me – a woman who's spoken in front of audiences since I was small, trained in and competed in 'oral presentation' in school, spent my 20s on camera and behind a microphone – into paroxysms of fear. Dread of public speaking came late to me. It was in 2010, after *The Virtual Revolution* series went out on BBC Two and around the world, that I found myself disassociating on stage, hearing my voice come from someone else's mouth, my brain catching up with what I was saying several seconds after my body formed the words. It was as if I was being manipulated by an invisible puppeteer.

In the latest series of *Digital Human*, we speak to a woman named Jane Charlton. She uses similar words to describe her experiences with chronic depersonalisation disorder. But her feelings of being separate from herself occur all the time, rather than on stage. So she has learned to self-medicate by being with other people, using their physical presence as an anchor for her own being-ness.

For someone who experiences depersonalisation as a result of the most common social anxiety – public speaking – the last thing I want to do is be with people. I want to run away

"PUBLIC SPEAKING SENDS ME INTO PAROXYSMS OF FEAR" and sob. But there is hope for the many people who find themselves in this situation. Research published in the journal Decision in December 2017 pointed to mindfulness, the popular practice of meditation and just being, as an effective treatment. Another paper published in *Behavior* Therapy in March this year, said that momentarily becoming aware of one's breath, a smell, or a sound is enough to reduce the force of fear. In that study, the researchers took a group of people who'd been treated for public speaking anxiety, and exposed them to more public speaking. They gave a stimulus – either a ball, the sound of white noise, or a peppermint scent – to half the test subjects. These sensations were intended to remind the person that public speaking is safe, and not going to result in some kind of hideous underwear-exposing outcome. These folks showed less anxiety – in terms of hearts pumping – than those who had to stand up in front of an audience staring blankly at them. Even writing this, I'm getting sweaty palms. Excuse me: I'm going to put my head in the mint plant to calm down.

Now, I've also learned to self-medicate. I started public speaking again a couple of years ago, but now I do it as if I'm doing a live radio show. I use props, clips of prerecorded interviews, a script, music and sound effects. It takes me out of myself. It's the equivalent of a clinical herbal nosegay, and it's entertaining for the audience. But, for those moments when the terror rises from the depths of my soul and grips my heart with its icy hand, I know that I can return to my body with a breath or a memory, and that public speaking can become as enjoyable as it once was.



BEATING AIR POLLUTION BY BIKE



TWO

Michael Mosley is a science writer and broadcaster, who presents *Trust Me, I'm A Doctor* on BBC Two. His latest book is *The Clever Guts Diet* (£8.99, Short Books).

uch of my working life is spent in London and I cycle everywhere. It's a fast, convenient way to get around, but I do worry about the air I'm breathing. When it comes to air pollution, London comes out badly. So what is the best way to get around a busy city if you want to minimise your exposure? Walking, driving, cycling, or the Underground?

The story around air pollution is confusing. Six years ago I bought a diesel car. I'd read that diesel produces less carbon dioxide per mile than petrol, so I thought I was doing my bit for the environment. It turns out that I've been contributing to the nearly 40,000 premature deaths that happen every year in the UK as a result of air pollution. This is more than 20 times the number of people that die in road accidents and is only exceeded by the 80,000 who die every year as a result of smoking.

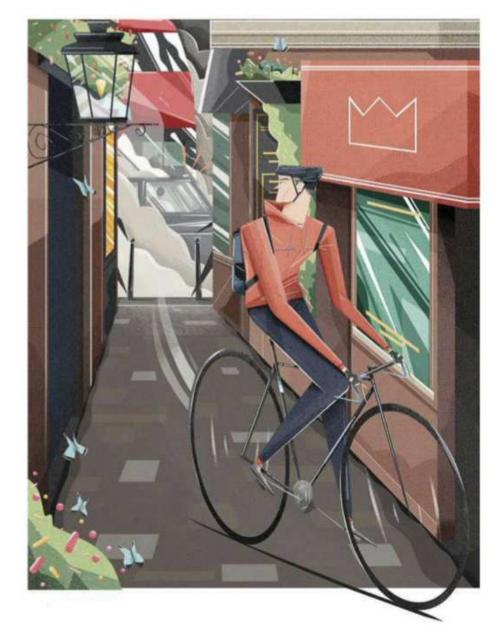
The trouble with diesel is that it produces a lot of nitrous oxide, which irritates the lungs, and ozone, which is also bad for the lungs. Ozone is formed when nitrous oxides and other volatile organic compounds react with sunlight, so levels can get spectacularly high during the summer.

As well as these gases, diesel engines produce lots of tiny specks of particulate matter (PM). These specks are so small that they can penetrate deep into your lungs, carrying with them a host of unburnt combustion components. These in turn trigger reactions that damage your blood vessel walls, contributing to heart disease, type 2 diabetes and Alzheimer's.

So when I'm cycling around London I'm inhaling all this stuff, which has to be bad for me. But how bad is bad? To find out I took to the streets of London wearing a pollution monitoring device. I walked from the Strand to Marble Arch, a distance of about five kilometres (three miles). Then I cycled back, but taking quieter back streets.

Finally, I jumped into the back of a taxi and went another five kilometres, this time through relatively heavy traffic.

"I DO WORRY ABOUT THE AIR I'M BREATHING WHEN I'M IN LONDON"



So what happened? Well, when I walked to Marble Arch the route I took was congested with buses and taxis, and the device I was wearing recorded an impressive rise in the levels of pollutants in the air I was breathing. When I returned down the back streets on my bike I was reassured to see that the levels dropped off really dramatically.

But the highest spikes, suggesting the worst levels of pollution, were when I was sitting in the back of the taxi. That's because if you are sitting in a car in traffic then the air inlet of your vehicle is going to be right behind the exhaust pipe of the vehicles in front.

You can turn off the air inlets and close the windows, which will make some difference, but the fact is that when you are stuck in traffic you are sitting in a giant pool of invisible pollution to which you are also contributing.

I didn't try travelling on the London Underground, but I suspect that if I had then the results would have been even worse. A study last year by the University of Surrey found that people travelling by the Underground were breathing in far larger amounts of damaging PMs than those who were travelling by bus or car. So I am delighted to say that cycling is not only incredibly convenient but also one of the best ways of travelling around while avoiding air pollution.

You could spend a lot of money on a sophisticated mask with active charcoal filters that will take out the gases, but you'll still be breathing in tiny particles. My best advice is to do what I do now, and take the quiet back streets. It takes a little longer, but it makes me appreciate what a wonderful city London is. Despite the pollution. •



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WANTED

1 FESTIVAL CHIC

You'll be the talk of tent-town when you're hunkered down in this geodesic masterpiece. The four-season tent is supported by blow-up struts, so it's erected within a mere five or six pumps. Better still, your poles won't snap if a storm hits.

Heimplanet Backdoor €980 (£875 approx), heimplanet.com 2 SUPER STORAGE

Stick this USB device into your iPhone and it'll back up all your photos to clear space for the next round of snaps. If you need films to get you through long journeys, you can watch them straight from the iXpand, too.

SanDisk iXpand £26.99, sandisk.co.uk 3 SEGWAY SKATES

These electric skates look impossible to balance on, but that's what we thought about the first Segways. In practice, you'll find scooting around at 12km per hour takes surprisingly little effort, and you'll only look a *little* bit silly...

Segway Drift 1 €399 (£360 approx), segway.com

4 COOKING WITH LIGHT

Forget pre-heating – this oven can heat from cold to 260°C in less than a second, because it cooks with pure light. Order food using a subscription and control the oven via an app. Bin that butane stove and join the future!

Brava Smart Oven \$995 (£765 approx), brava.com 5 SHUT-IN SOUND

Audeze has expanded its LCD Series with a closed-back model that greatly reduces ambient noise. It offers the same great sound as Audeze's original planar magnetic headphones, but now free of any external distractions.

Audeze LCD2 Closed-Back Headphones £699, audeze.com

6 BATTERY BOARD

This new battery-powered surfboard has a top speed of 56km/h and will sustain 40 minutes of riding on one charge. But the name surfboard might be a stretch – it looks best suited for zooming along on flat water.

Awake RAVIK

€18,900 (£16,800 approx), awakeboards.com

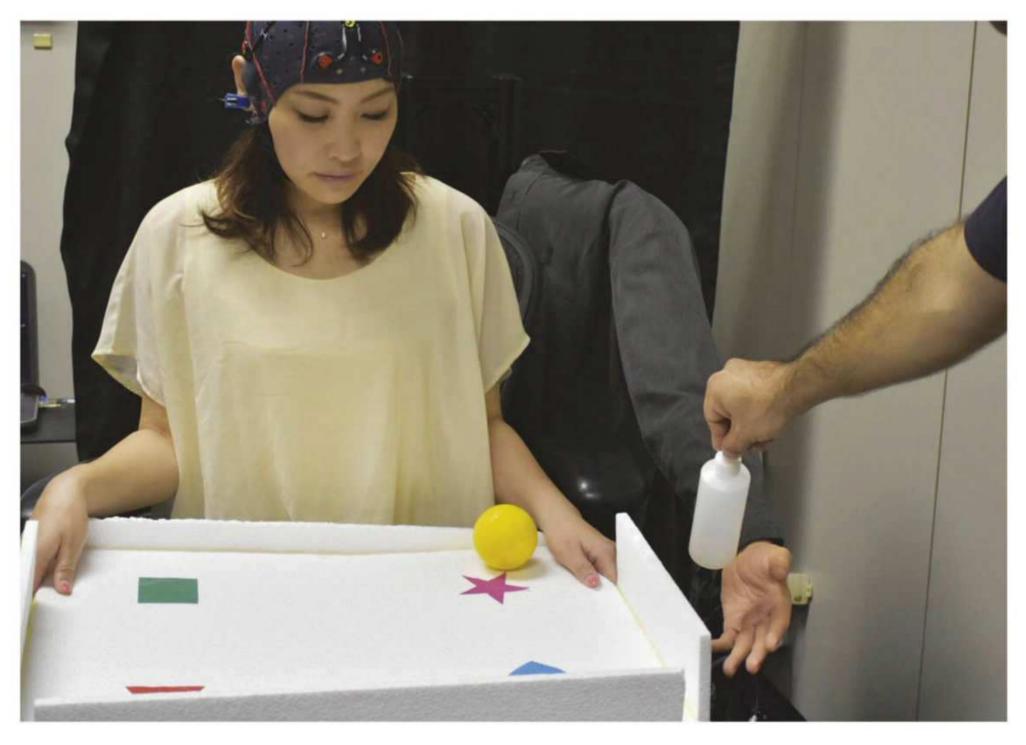


The shoes are modelled on the Zoom Vapourfly 4% running shoe, which was worn by the winners of the Boston, Berlin, New York and Chicago marathons. The Vapourfly features a carbon-fibre plate, which makes the shoe very fast, but also very firm – and this has been removed from the Zoom Pegasus Turbo. That makes the Pegasus a more comfortable fit: it's designed for people who want a lot of punch, but in an everyday training shoe.

That punch comes from the ZoomX

foam that cushions the shoe. Every stride you take when running compresses your shoe's foam, and the foam springs back when your foot leaves the ground. The closer the foam gets to returning to its original shape, the more energy you get back. The ZoomX foam used in Zoom Pegasus Turbo delivers an 85 per cent energy return, Nike's most efficient to date. They shoes are also superlightweight, with a mid-sized shoe weighing in between 200 and 240g. With the Zoom Pegasus Turbo's high-tech foam and comfortable design, we're going to need a new excuse for our shoddy performance on sluggish training days.

Nike Zoom Pegasus Turbo £159.95, nike.com



ROBOTICS

TWO ARMS GOOD, THREE ARMS BETTER

Because two arms just aren't enough, researchers from the Hiroshi Ishiguro Laboratory in Kyoto, Japan, have taught volunteers to control a robotic third arm through a brain-machine interface.

Participants in the experiment were challenged to balance a ball on a board using their hands, and pick up a bottle using a robotic third arm. Fifteen subjects took part, and eight of them managed the task successfully.

For now, the robot arm is quite basic: it can only open and close its hand. The brain-machine interface is similarly rudimentary: it's a cap fitted with electrodes that measures the brain's electrical signals. Before the test, participants imagined opening and closing the robotic hand, and those brain signals were recorded and turned into an instruction for the robotic arm.

Uses for extra limbs have already established. An MIT concept device developed in 2012 saw users wear extra limbs like a backpack. They were used to hold tools and parts in manufacturing, and to support the user in sitting positions. But while it's a long way off being practical, this is the first time that an extra limb has been controlled straight from the brain. In the past, robotic prosthetics have been controlled using signals from muscles or external joysticks, and they've usually been intended as replacement limbs, not supplementary ones.

The researchers also noted that success in the task depended heavily on the participants' ability to multitask. They suggested that operating the extra limb through the brain-machine interface might help users improve their multitasking abilities.

The participants had to move a ball between coloured shapes on a board, while grabbing a bottle with a robot hand

MEDICINE

X-RAYS REACH NEW DIMENSIONS

MARS Bioimaging Ltd has revealed a firstof-its-kind X-ray scanner that creates 3D colour images of muscle, fat and skin, as well as the usual information about bone.

Normal X-rays pass through soft structures and are absorbed by bone, with images then created based on levels of absorption. This new scanner records the precise energy levels of the X-rays as they hit each particle in the section of the body that's being scanned. Those measurements are then translated into different colours, presenting a realistic-looking image that differentiates between components like fat, water, muscle and bone.

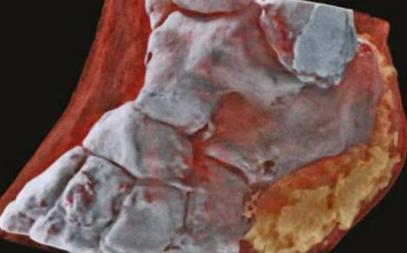
While traditional X-rays are usually sufficient for picking up fractures, they reveal very little about the surrounding structures. A small version of the MARS scanner has already been used to study

X-ray images will soon be more detailed than ever before. From top to bottom: wrist; left view of ankle; right view of ankle

cancer, vascular disease, and bone and joint health, with promising early results. In the coming months, the scanner will be used in a clinical trial on orthopaedic and rheumatology patients in New Zealand, where MARS Bioimaging is based.

The MediPix3 pixel-detector technology involved was originally developed at CERN for particle tracking in the Large Hadron Collider, and has since been modified by MARS for medical applications.





TECH BYTES



CLOCKING UP MILES

Self-driving ride-share company Waymo recently announced its cars have driven 12.87 million kilometres on public roads. They'd accrued 6.44 million kilometres from 2009 until November 2017, and doubled that distance in the last eight months. The company plans to launch a commercial service this year.

LOW-STRESS DENTISTS

Researchers at Colombia University's Center for Precision Dental Medicine are equipping chairs with biofeedback systems that will measure patients' heart rates and oxygen levels during procedures. It's designed to track patients' stress levels so that dentists can take steps to make them more comfortable.

UNDERWATER INTERNET

Thousands of miles of internet cables, data centres and servers could be underwater by 2030 due to rising sea levels, according to a new study. Underground cables are resistant to water but not complete submersion, so rising sea levels could cause widespread outages.

TEVE SAYERS/THESECRETSTUDIO.NET

ON TEST: YOUR BATTERY-POWERED COMMUTE

These will add a bit of fun to the weekday grind...



SEGWAY NINEBOT KICKSCOOTER ES2

It's hard to say exactly why, but there's just something horribly conspicuous about a grown man on an electric scooter. Even in Bristol, where we've seen people going to work on unicycles and penny-farthings. But if you can put your vanity to one side, the Ninebot by Segway is actually a fine way to get around.

The motor kicks in after a push and manages a reasonable top speed of 25km/h (15.5mph). Large wheels and shock absorbers help the Ninebot skip over most surfaces, and the LED headlight makes it visible enough to ride at night. It's a brilliant piece of kit, albeit one that's perhaps, like other Segways before it, just a little ahead of its time.

From £549, segway.com

BROMPTON ELECTRIC

The designers of the new Brompton Electric have retained the classic Brompton geometry here, but added a motor to the front hub and a battery pack over the front wheel. That battery pack tips the scales at 2.9kg and needs to be removed when you're carrying the bike – even without it, the bike weighs 13.4kg.

Still, the Brompton is a lot of fun. When accelerating, the motor kicked in with gusto, sending us flying along the flat with very little effort. On hills, the initial acceleration was great, but it wasn't as powerful as we'd have liked on longer climbs. That said, the bike still folds and stores easily, so if your commute mixes in trains or buses, it's a great option.

From £2,595, brompton.com

TOP SPEED:

25KM/H

(15.5MPH)

RANGE:

Street legal

In the UK, e-bikes can be used everywhere normal bikes can, as long as they don't provide any assistance over 25km/h (15.5mph). Powered skateboards and scooters technically aren't legal on roads, cycle paths or footpaths, but this is rarely enforced. You've been warned.



BOOSTED BOARD STEALTH

For normal skateboards you want empty roads, good weather, smooth tarmac and, ideally, a hill to roll down. This makes them pretty useless as far as commuting goes (I've tried), but the Stealth blasts through these limitations with a 2,100W motor that propelled my weary frame uphill, over cobbles and even past traffic. The accompanying app and hand remote give you intuitive control over your speed and let you brake quickly or slow your descent down a hill. The Stealth is heavy, awkward to carry, and demands you wear a helmet (at top speed you're toeing the line between fun and dangerous) – but it will also inject pure, childish joy into any journey.

From £1,499, boostedboards.com



The Coboc ONE Soho looks like a vintage single-speed from 1960s London, complete with retro bars and a Brooks saddle. Its electronics are well hidden in the slim frame, and it retains a sleek look with no visible evidence of a motor or battery.

The bike's power becomes obvious, however, as soon as you start riding. The motor assists pedalling in a smooth, consistent manner, and makes you feel like an exceptionally strong cyclist, rather than someone who's being pushed along. It's also very light for a full-sized electric bike, weighing in at 13.7kg. If you like the convenience of e-bikes but still want to look like a hipster, this exceptionally comfortable and stylish commuter is the one for you.

From £3,715, coboc.biz

FIRST DRIVE: JAGUAR I-PACE

DANIEL BENNETT wonders whether the British car company can shake off its old-fashioned image and take on Tesla, the upstart from Silicon Valley

JAGUAR I-PACE

PRICE: FROM £63,495 jaguar.co.uk

SPEC:

MODEL TESTED: JAGUAR I-PACE FIRST EDITION (£81,495)

RANGE: 480KM (298 MILES)

0-60MPH: 4.5 SECS

BHP: 349

BATTERY: 90KWH, 388V LITHIUM-ION

TOP RIGHT: There's plenty of room in the back to accommodate passengers in typical Jaguar luxury

BELOW: It's in the front of the cabin that the I-Pace's 21st-Century credentials are clear to see The combustion engine's days are numbered. Those smelly, noisy motors will slowly be forced out of cities as we creep towards 2040, after which you'll no longer be able to buy a new car in the UK unless it can travel 50 miles on electric power alone. In order to clean up the air we breathe, it seems petrol and diesel will go the way of the steam train, and the horse and carriage before it. It's a necessary progression, but one we'll be slightly sad to see.

That's the backdrop to the arrival of the Jaguar I-Pace, the first real all-electric rival to Tesla's premium Model S. It's a big leap for the British company, but is it good enough to ease the pain of parting with the engines we've come to love?

IN THE DRIVING SEAT

On first impressions, at least, the answer is yes. I've never been a fan of SUVs, but the Jaguar is quite literally head-turning even on the streets of New York, where we tested the car ahead of the final race of the Formula E season.

With the batteries under the chassis and an electric motor at each end, Jaguar's taken the opportunity to shorten the bonnet and pull the cabin almost over the front wheels. Despite its size, it looks like a sprinter ready to bolt. And Jaguar's broken with convention inside, too, with a screen-laden central console that rises up between the driver and passenger seat. The interior looks Silicon Valley, but still has plenty of Jaguar personality.

Beneath the surface, the dual motors provide four-wheel drive, producing 349bhp and an eyewidening 513lb/ft of torque. It's a big car, but that torque hurls the I-Pace forward, delivering it to 60mph in 4.5 seconds – quick enough to leave a lot of sports cars in its dust. It's the welcome new reality of electric cars: because the power delivery



is instant, they'll *all* be quick, even SUVs. That said, a heavy foot will shorten the reported 298-mile range – a realistic figure would be closer to the 200-mile mark. If you need to go further, then a 100kW charger (of which there are 2,000 being scattered across the UK this year) will recharge your batteries in 40 minutes. A 7kW home charger will get to 80 per cent in 10 hours.

The batteries lining the bottom of the car help keep the centre of gravity low, which means it's surprisingly obedient in the corners for such a hefty vehicle. And special mention, unusually, goes to the sound Jaguar's bestowed upon the I-Pace — a low, growly space-age hum that beats any electric vehicle we've sat in.

So far so good, but there are few things we miss. The I-Pace is a brilliant car to drive, particularly for an SUV, but battery-powered cars all share the same characteristics. They're fairly uniform: instant power with a silent ride that's occasionally a bit bumpy in town. Those that care about their drive will miss the character an engine can provide, as well as the noise. The infrastructure is also still an issue: although charging stations are near-ubiquitous, there are too many types, each with their own charging time.

THE VERDICT

Ultimately, the I-Pace is a brilliant piece of design, sat atop a great car. It's comfortable, spacious and rapid, and its range covers most journeys. It also puts a smile on our faces to see a British brand lead innovation in the electric charge, redefining what Jaguar stands for in the process. It's a worthy competitor to Tesla's offering, but will appeal to different customers. As the infrastructure starts to catch up with the quality of the electric cars being produced, there are going to be fewer and fewer excuses not to leave fossil fuels behind, and that can only be a good thing.







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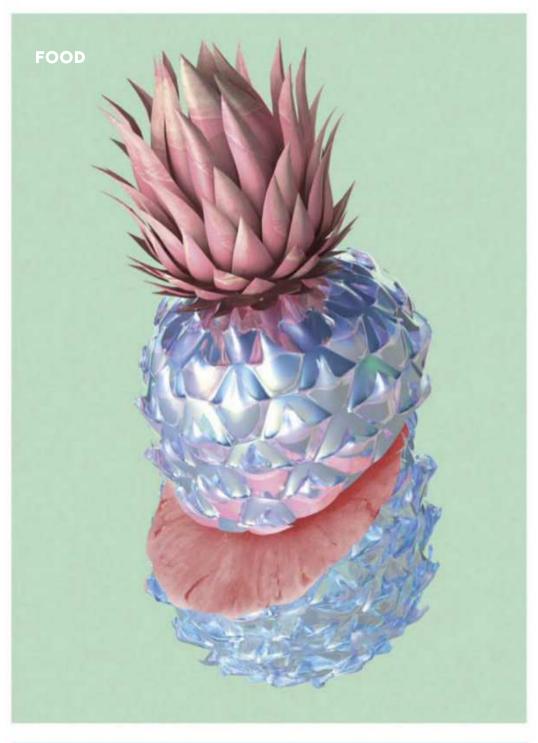
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We've all heard that the future menu may involve less meat and dairy. But don't worry, we could have customised diets, outlandish vegetables, robot chefs and guilt-free gorging to look forward to instead. And we reckon that makes up for missing out on the odd sausage

WORDS: DR STUART FARRIMOND



efore 1928, no one had tasted bubblegum. In the late 1930s, frozen cream desserts threw off their reputation for being as hard as rock with the US

invention of soft-serve ice cream (often called Mr Whippy in the UK). Popping candy introduced children's mouths to a bizarre effervescence 20 years later. And in the late 1990s, Red Bull showcased a strange medicinal flavour that's since become synonymous with energy drinks. The foods we eat are always evolving and new tastes are being created. By 2028, you can expect to be tucking into foods unlike anything you've experienced before. ▶

IN 2028 FOOD WILL BE...

... TAILORED TO YOUR GENOME







Today, we know that healthy eating is important to keep our bodies in tip-top condition. This link between diet and health was first 'proved' in the mid-1800s by Scottish naval surgeon Dr Joseph Lind, who is credited with running one of the earliest ever clinical controlled trials. His study demonstrated that citrus fruits could protect sailors from scurvy. The watershed finding set the stage for lemons and limes to be issued as standard in sailors' rations, and showed how healthy eating can save untold numbers of lives.

These days, science may have dissected almost every element of our diet, but many of us still feel at sea. Even when sticking to official advice, healthy foods that seem to energise one person can cause another to feel fatigued and bloated. In 2015, a team of scientists from Israel tracked blood sugar levels in the blood of 800 people over several days, making the surprising discovery that individuals' biological response to identical foods varied wildly. Some people had a blood glucose 'spike' after eating sugary ice cream, while others' glucose levels only increased with starchy rice – a finding at odds with conventional wisdom.

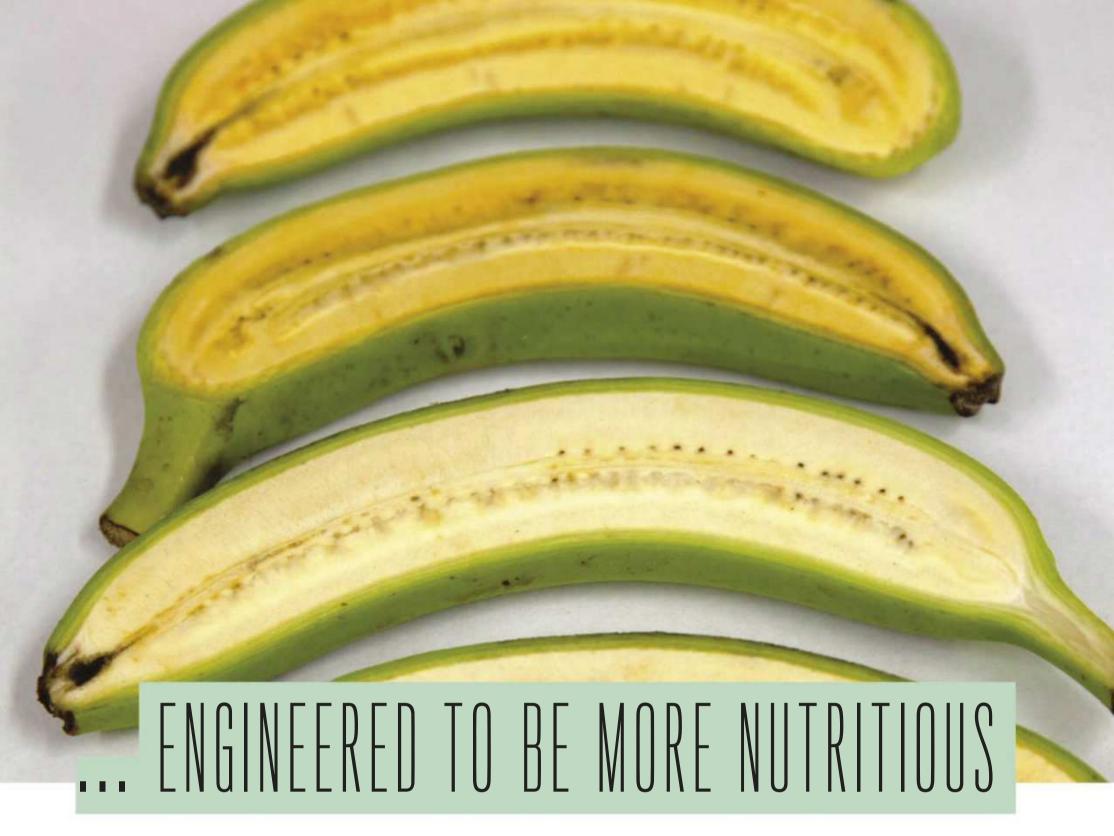
Our bodies' idiosyncratic handling of nutrients seems to be down to our genetics, the microbes in our gut, and variations in our organs' internal physiology. Clinical trials like those pioneered by Lind have given us general dietary guidelines, but nutrition research tends to assume all humans are the same, and so can miss the nuances and specific needs of the individual.

In the next 10 years, the emerging field of 'personalised nutrition' will use genetic tests to fill in those gaps to offer healthy eating guidance tailored to the individual. Some companies, so-called 'nutrigenetics services', already test your DNA and offer dietary advice – but the advice can be hit-and-miss. By 2028, we will understand much more about our genetics. Dr Jeffrey Blumberg, a professor of nutrition science and policy at Tufts University in Massachusetts, is one of the most outspoken advocates of this new science. He insists that DNA testing will unlock personalised nutrition. "I'll be able to tell you what kinds of fruits, what kinds of vegetables and what kinds of wholegrains you should be choosing, or exactly how often," he says.

Sadly, personalised nutrition looks set to make cooking meals for the whole family just that little bit more taxing.

"In the next 10 years, the emerging field of personalised nutrition' will offer healthy eating guidance tailored to the individual"





'Natural' is a buzz term food marketeers love to use, but barely any of our current produce ever existed in the natural world. The fruit and vegetables that we enjoy today have been selectively bred over thousands of years, often mutated out of all recognition from the original wild crop. Carrots weren't originally orange, they were scrawny and white; peaches once resembled cherries and tasted salty; watermelons were small, round, hard and bitter; aubergines used to look like white eggs.

But the selective breeding for bulky and tasty traits, combined with intensive farming practices, has sometimes come at a nutritional cost. Protein, calcium, phosphorus, iron, riboflavin (vitamin B2) and vitamin C have all waned in fruit and vegetables over the past century, with today's vegetables having about two-thirds of the minerals they used to have.

By 2028, genetics and biomolecular science should have redressed the balance, so that DNA from one organism is inserted into another, eliminating the need to undertake generations of selective breeding to acquire desirable traits.

Just last year, researchers from Australia showcased a banana with high levels of provitamin A, an important nutrient not normally present in the fruit. To create this fruit, the researchers snipped out genes from a specific type of Papua New Guinean banana that's naturally high in provitamin A, then inserted them into the common banana variety.

More controversially, DNA can be transplanted from completely different organisms to create varieties that would never occur with selective breeding. Corn has been successfully given a boost of methionine – a key nutrient missing in the cereal – by

splicing in DNA from a bacterium. Even the genetic code itself can be edited to develop 'superpowers': in 2008, for example, researchers created modified carrots that increase the body's absorption of calcium.

There have been hundreds of examples of these incredible botanical creations: potatoes, corn and rice containing more protein; linseed having more omega-3 and omega-6 fats; tomatoes containing antioxidants originally found in snapdragons; and lettuce that carries iron in a form that's easily digestible by the body.

Over the next ten years, the number of nutritionally enhanced crops will probably explode. Precise DNA-editing technology – namely a technique called CRISPR-Cas9 – now allows alteration of plant genetic code with unprecedented accuracy. Get ready for tasty apples with all the goodness of their bitter forebears, peanuts that don't trigger allergies, and lentils that have a protein content equivalent to meat. It will be like creating the orange carrot all over again!

ABOVE LEFT: Foods and flavours are always evolving. Bubblegum – demonstrated here at a bubble-blowing contest in the 1950s – was an invention of the 20th Century

ABOVE: The golden banana (top) is a more orange colour than a standard banana (bottom), thanks to higher levels of provitamin A. These engineered bananas could be used to improve the nutritional content of bananas in Uganda, where the fruit makes up a major part of the diet



... DIFFERENT FROM ANYTHING YOU HAVE TASTED BEFORE

New flavours arrive unpredictably as food manufacturers create new products. Silicon Valley – well known for attracting the brightest minds – is becoming the global hub for food innovation. A start-up currently making waves is Impossible Foods, which has created a meat-free burger that sizzles in the pan, tastes like meat and 'bleeds'. Designed to be sustainable and environmentally friendly, the patties are made with wheat protein, coconut oil, potato protein, and flavourings. The secret ingredient is heme – the oxygen-carrying molecule that makes both meat and blood red - and seems to give meat much of its flavour. The heme that Impossible Foods uses has been extracted from plants and produced using fermentation. It's a growth industry, with competitors such as Beyond Meat and Moving Mountains cooking up similar burgers, and plans are afoot for plant-based steaks and chicken. It doesn't stop there, however: other start-ups are pioneering animal-free milk and egg whites. Expect to get used to the new tastes of meat-free meat and dairy-free dairy.

It's now been more than a decade since chef Heston Blumenthal first served his famous 'sound of the seas' dish, for which diners listened to a recording of breaking waves to heighten the salty flavours of seafood. It is well established that all senses inform the flavour of food: desserts taste creamier if served in a round bowl rather than on a square plate; background hissing or humming makes food taste less sweet; and crisps feel softer if we can't hear them crunching in the mouth. The emerging field of 'neurogastronomy' brings together our latest understanding of neurology and food science and will be a big player in our 2028 dining.

Today, you might hear James Blunt crooning in your favourite eatery, but in the restaurant of 2028, there may be aromatic mists, subtle sound effects and controlled lighting, all optimised to make your steak and chips taste better than you thought possible. At home, augmented reality headsets that superimpose digital imagery on the real world could offer a tranquil seascape for a fish dish, or the wilds of Texas for barbecued ribs.

Unusual processed foods will make a splash in the years to come, including novelties like edible spray paint, algae protein snack bars, beer made with wastewater, and even lollipops designed to cure hiccups. We don't know exactly what will be on tomorrow's supermarket shelves (if supermarkets still exist, that is) due to the secretive nature of the multinational food corporations. But we do know that ice cream and chocolate that don't melt in warm weather are definitely under development. Nanotechnology is going to feature: researchers are currently devising nanoparticles that give delayed bursts of flavour in the mouth, and earlier this year, a team of chemists created tiny magnetic particles that bind to and remove off-tasting flavour compounds in red wine while preserving its full aroma.

Cookbooks in 2028 will have some weird recipes. By analysing foods for their flavour compounds – aroma-carrying substances that convey flavour – ingredients can be paired to create novel experiences. In 2016, researchers from the International Society of Neurogastronomy demonstrated a menu with hitherto untried ingredient blends, designed to be flavourful for people who had lost their sense of taste and smell through chemotherapy. A lip-smacking highlight was: clementine upside-down cake

with a dab of basil and pistachio pesto, crowned with a scoop of olive oil gelato.

Perhaps the most outlandish proposal to enhance the eating experience is to 'hack' the brain. The Defense Advanced Research Projects Agency (DARPA) is designing implantable 'neural interfaces' that aim to boost human senses by transmitting high-resolution audiovisual information, and potentially smells and tastes, directly to the brain.

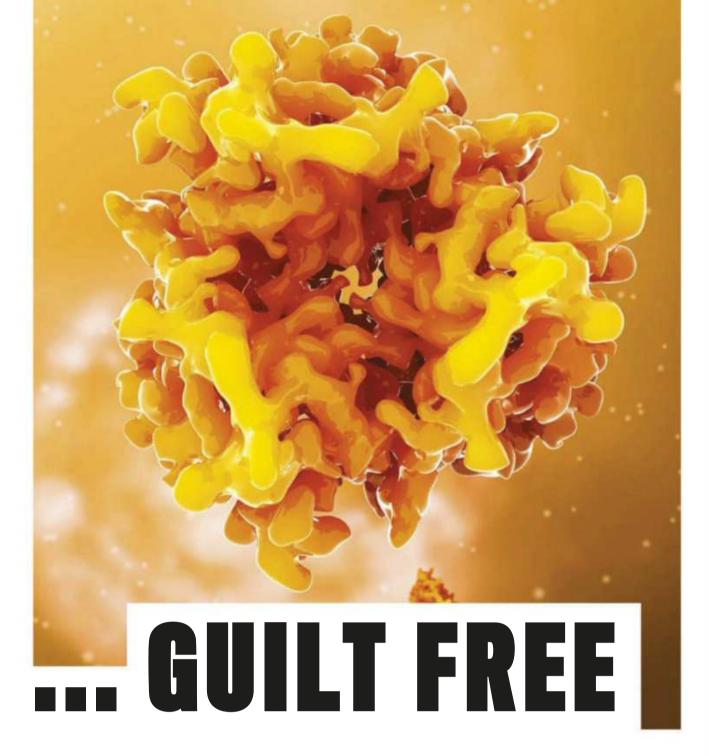
ABOVE LEFT: Impossible Foods is one company that has been making plant-based burgers. With many people increasingly concerned about ethics, land usage and global warming, these 'meats' are likely to become regular fixtures on the menu

RIGHT: Leptin is a hormone released by fat cells, signifying when fat stores are sufficient. In future, we may be able to manipulate hormone levels to stop us gaining weight

BELOW: Edible spray paints can add colour and shimmer to any sort of food. Metallic gold lobster, anyone?

"Perhaps the most outlandish proposal to enhance the eating experience is to directly 'hack' the brain"





We just keep getting heavier. Today around 40 per cent of all adults are overweight or obese and every single nation on Earth is getting fatter. Obesity-related diseases, such as type 2 diabetes, are soaring on a trajectory that will cripple many health services. Most troublingly, there have been no success stories in the past 33 years – not one country has been able to halt the growth of the bulge. Processed, calorie-dense foods continue to become more widely available worldwide and, short of an international catastrophe like a global famine or mass outbreak of war, turning the tide is going to take some truly innovative thinking.

A short-term solution is to re-engineer calorific 'junk' food to have less fat, sugar, salt and fewer calories, while still giving the same satisfaction. There are artificial sweeteners, but they can have unpleasant side effects and can't be cooked as sugar can. Low-calorie sugar substitutes, such as sugar-alcohols like sorbitol, taste like the real thing but cause flatulence and diarrhoea if eaten excessively. But food technologists have managed to coat inert mineral particles with sugar, increasing the surface area that contacts the tongue, so that less sugar can be used to provide the same sweetness.

In the longer term, fine-tuning our biology could allow us to eat without guilt. Few

people realise that our appetite is precisely regulated. Overeat on a Monday, and you usually eat less on Tuesday and Wednesday. Our hunger is usually set to a level almost identical to the number of calories we need. Unfortunately, the hunger 'thermostat' is set a little too high, by an average of about 0.4 per cent (or 11 calories a day). Left to our own devices, we will each tend to eat an extra peanut's worth of calories each day. That doesn't sound like much, but it adds up to nearly half a kilogramme weight gain each year. Our unfortunate tendency to develop 'middle-aged spread' has presumably evolved as an insurance against the next famine.

The hunt is on to nudge the appetite set point down by 11 calories or more. Many hormones swirl around the blood to tell us when to eat and when to stop. One hormone, CCK, is released by the gut when food enters it, making us feel full. Another hormone, leptin, is released by body fat and apparently tells the body when our fat stores are adequate. It's a complex picture and attempts at manipulating individual hormone levels have been unsuccessful. Everyone is hoping that we will soon untangle the web of brainhormone messages and managed to devise supplements, foods or medicine that can make a tiny tweak to the dial.

FOODS WE'LL BE EATING MORE OF

ALGAE and SEAWEED:

Stu kr m e ei sto

Studies show that knowing how bad meat is for the environment isn't enough to make us stop us eating it. But people are more likely to change habits if there is

an alternative that's healthier. Algae and seaweed are sustainable and hold the promise of being the 'superfood' for the next generation. They are rich in protein and healthy fats, and can provide more calcium than milk, more potassium than a banana, and more iron than beef.

JELLYFISH: Hated by swimmers and surfers alike, these animals are said to be doing quite well out of climate change and overfishing, and are apparently on the rise.

Rather than fear them, we should think about eating them, says the UN's Food and Agriculture Organisation. The squishy creatures can be turned into crisps and chips, but they don't have an awful lot of flavour, so it's time to get creative with those sauces and seasonings!

FOODS WE'LL BE EATING LESS OF

coffee: You wouldn't know it by the ever-rising number of coffee shops, but soon there may not be enough coffee to go around. Extreme weather and

proliferating pests are making crop yields unreliable, which means prices are being pushed up.
Switching to the hardier *Coffea robusta* variety will help keep the baristas in business, but we can expect a harsher, inferior flavour.

CHOCOLATE: Farmers in
West Africa are being
hit hard by climate
change, and land is
being gobbled up
with unsustainable
farming practices.
We are facing a global
cocoa bean shortfall of

one million tonnes by 2020.









- Moley Robotics' chef is modelled on the pros, so you can let it carry on with the cooking while you relax
- 2 This torte features a thick chocolate coating that plays a tune of your choice when popped in a record player
- 3 A head 3D printed from butter, by Natural Machines
- A Natural Machines' innovative 3D printing machine created these crackers shaped like coral. Could we all have an appliance like this in our kitchens in 2028?

Kitchen creativity has few limits. From Weetabix ice cream to liquid nitrogen cocktail balls, exciting dishes are made by chefs who love to surprise, but few such culinary masterpieces make it into the home, owing to a reliance on specialist equipment and professional skills. Expect that to change as equipment becomes more affordable. Even today, the sous-vide water bath that was once reserved for fine dining restaurants can be purchased for less than a set of pans. In the coming years, the spiraliser will have been eclipsed by a handheld spherificator or foam-making espuma gun. For the ambitious home cook, getting creative is going to be a lot more fun.

When skills are lacking, a robotic sous-chef may lend a helping hand. Imagine being able to send a message your Robo-Chef while on the commute home to prepare a recipe of your choice. Within moments, android arms will be gathering ingredients from the fridge, julienning the turnips and deboning the chicken.

It's not completely pie-in-the-sky, either. UK-based Moley Robotics has already developed a 'robotic kitchen', set for consumer release this year. Consisting of two articulated arms, cooking hobs, oven and touchscreen interface, this is a robot that can chop, whisk, stir, pour and clean. It's no clumsy Dalek either: each hand has 20 motors, 24 joints and 129 sensors to mimic the movements of human hands. Skills are 'learnt' by replicating the movements of chefs and other cooks, and their recipes can be selected via an iTunes-like recipe catalogue. The speed and dexterity of the robotic kitchen will have foodies salivating at the possibilities. But with the first devices expected to cost around £10,000 each, it might be worth holding out until they throw in a dishwasher.

Elsewhere, 3D-printed food offers endless opportunities for creating intricate dishes that are impossible to create by human hands alone. Everything from toys to airplane parts, from prosthetics to clothing – even whole houses – are already being made with 3D printers. And the food frontier has been crossed. Custom sweets can be designed and made using sugar-

rich 'ink' to construct anything from interlocking candy cubes and chewable animal shapes, to lollipops in the shape of Queen Elizabeth's head.

Until recently, 3D printing has been sugar-based, but technology is emerging that reliably prints savoury and fresh ingredients. Natural Machines has developed one such kitchen appliance that can be loaded with multiple ingredient capsules to create and cook all manner of weird and wonderful foods. These include: crackers shaped like coral, hexagonal potato chips, heart-shaped pizzas and hollow croutons that dissolve in sauce. With the promise of cutting waste by repurposing 'ugly' food and offcuts for food capsules, Natural Machines has the potential to drastically reduce packaging and transport costs. Not yet sold on the idea? Imagine wowing your nearest and dearest by serving up the ultimate romantic meal finished off with a personalised chocolate torte, where an invisible series of grooves in the chocolate surface plays their favourite song when placed in a special 'record player'. Delicious! •

Dr Stuart Farrimond is a science and medical writer and educator. His new book, *The Science Of Spice: Understand Flavour Connections And Revolutionize Your Cooking* (£20, DK) is out in October.

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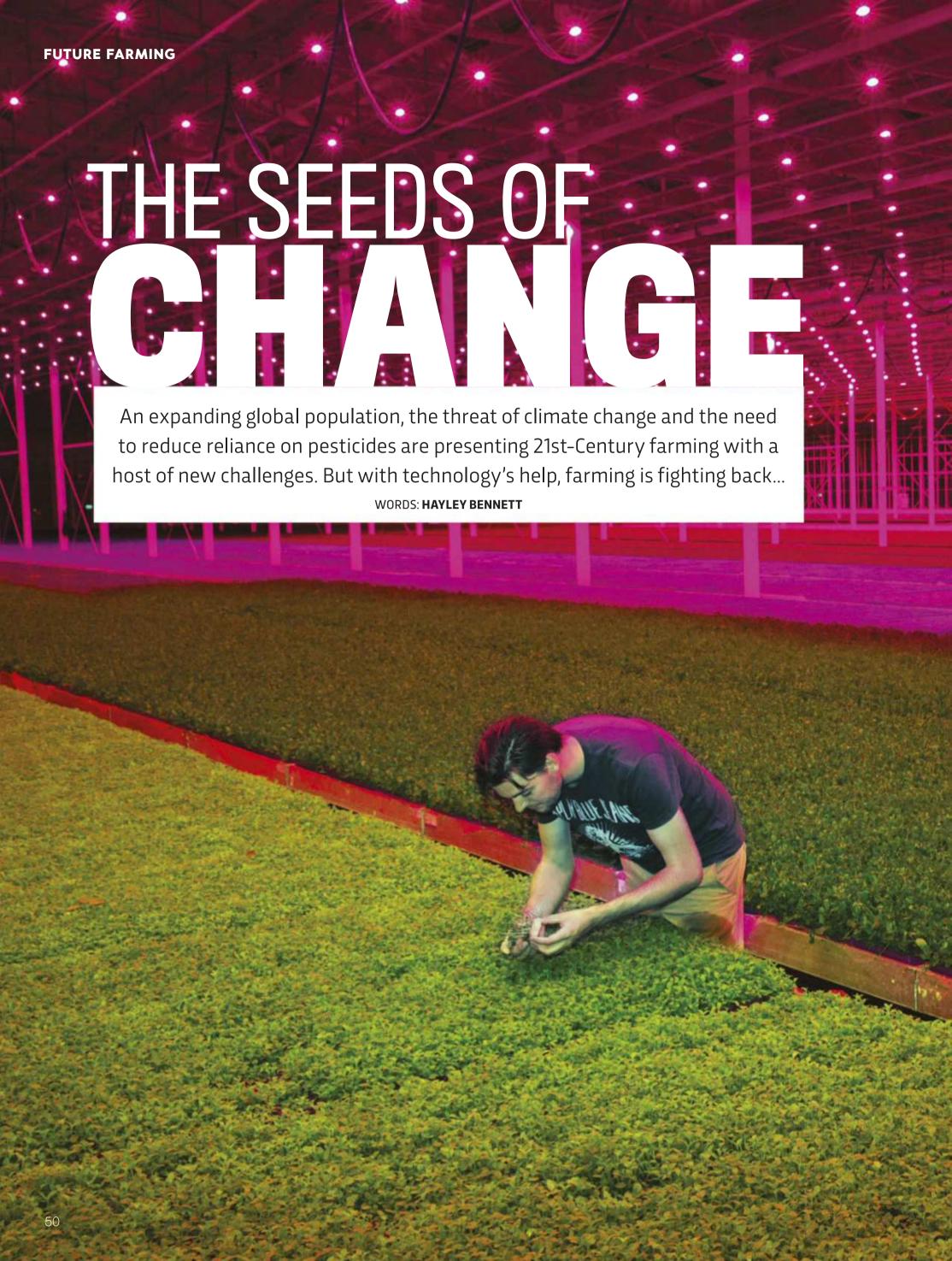
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► ON THE BEET COWRA, AUSTRALIA

In a typical field of beetroot you're battling against pigweed, purslane, velvetleaf and wild buckwheat, to name but a few unwanted plants. These invaders can be ousted with herbicides, but not without harming the beets. So you really want to avoid dousing your whole crop in chemicals, but sadly it's usually the most efficient way to keep weeds down.

Not, however, if you have a RIPPA robot, which can identify individual weeds and exterminate them by "microdosing" with herbicide. Its designers at the University of Sydney say their technology is affordable for farmers and could help them make cost savings by cutting down on their use of herbicides.





EDEN GREEN TECHNOLOGY, TEXAS AND COFCO WISDOM FARM, BEIJING, CHINA

Tilt your head slightly and the rows of cos lettuces below don't look too dissimilar to those growing in any farmer's field. Except for the lack of weeds, bugs, scarecrows and soil. Oh and the fact they're growing on a wall. Eden Green Technology's vertical greenhouse in Texas feeds its crops directly via their roots on a 24/7 basis. This means there's no mud to get in the way of the nutrients, apparently helping them to grow super-fast. Meanwhile, microjets cool down individual plants if they get hot. Eden Green's soilless salads hit Texas supermarkets in July this year.

Meanwhile, at Cofco's indoor farm in Beijing, hundreds of pot plants suspended in a vertical rotation system move in time to a silent waltz, precisely choreographed to catch the Sun's rays. The palatial glass building also incorporates vertical greenhouses for growing tomatoes on the vine.







▲ PIPE DREAMS

ROQUETTE FACTORY, KLOTZE, GERMANY

In the 1300s, Aztec fishermen skimmed blue-green algae from Lake Texcoco in Mexico and dried it to make cakes that they ate with corn or spicy sauces. Today, microalgae destined for nutritional powders and tablets are grown in tubular aquariums watched over by white-coated workers. At the Roquette factory in Germany, there are 500km of narrow glass growing tubes. These ensure maximum exposure to sunlight, enabling the algae to grow faster than in the depths of a murky pond. Touted as superfoods, microalgae such as spirulina and *Chlorella* are densely packed with protein, as well as compounds such as polyunsaturated fatty acids and sterols, which guard against heart disease and other conditions. This worker is surveying tubes filled with Odontella aurita, cultivated for its carotenoid content – it makes fucoxanthin, a pigment shown to kill cancer cells in the test tube.



◀SOWING THE SEEDS

WISCONSIN, USA

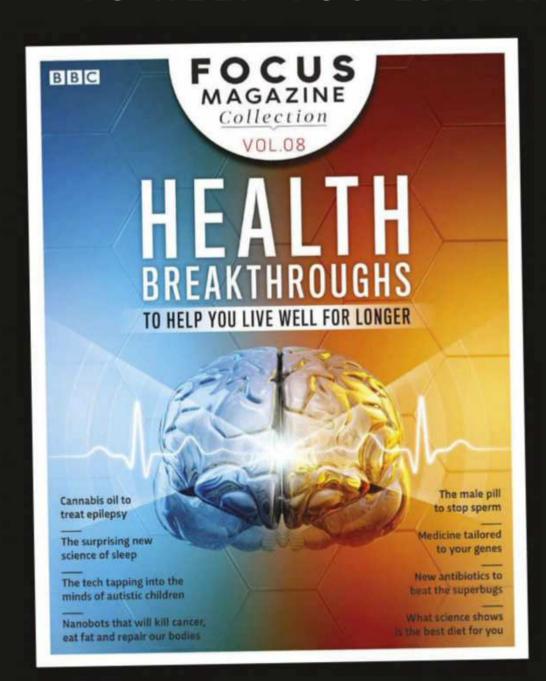
It may be hard to imagine a day when we'll teach our children that farmers sit in offices controlling their tractors via tablets, but that's the vision of Case IH, who previewed their autonomous tractor in 2016. With multiple vehicles, farmers could simply monitor progress as machines planted three different crops in three different fields.

The model seen planting seeds here is based on an existing Magnum tractor that could also be adapted for ploughing, tilling, harvesting and other tasks. It follows a preprogrammed map, is equipped with a raft of sensors to save it from crashing through hedgerows and can keep going all night, to bring in a bumper crop or take advantage of good weather.



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THE RISE OF THE FLAT EARTHERS

Flat Earthers







WE LIVE IN AN INCREASINGLY SCIENTIFIC WORLD, SO WHY DO CONSPIRACY THEORIES SEEM TO BE MORE POPULAR THAN EVER?

CONSPIRACY THEORIES

or more than 50 years, Gary Heather believed, unquestioningly, that the Earth is a globe. But one evening in August 2015, he was browsing YouTube at his home in Hampshire and found a video called

Flat Earth Clues. He watched all two hours, five minutes and 43 seconds of the film – and he wished it was longer.

He describes the moment as a kind of awakening: "You're having a cup of coffee, and you always have the same brand, and in your mind you think that brand is how coffee tastes. And then all of a sudden you have another brand of coffee, and at that moment you drink it, you instantly realise there are other flavours out there you didn't know existed."

Over the last three years, Heather has become a passionate Flat Earther, taking part in experiments to collect evidence calling into question the curvature of the Earth, and campaigning at Speakers' Corner in Hyde Park. He's far from alone. Heather co-organised the UK's first ever Flat Earth Convention in April this year, which saw some 260 Flat Earthers descend on a hotel in Birmingham for three days, with other conferences planned this year in Denver, USA and Edmonton, Canada. The Flat Earth Society's Twitter feed currently boasts over 55,000 followers.

Conspiracy theories are nothing new, but the rise of Flat Earthers in particular seems to have caught people's imagination, and stoked up their disbelief. So what is it that draws people to these theories, despite untold evidence to the contrary, and what does it reveal about society at large?

UNCOMMON BELIEFS

Heather, who goes by the name Gary John on social media, is a central figure in the UK's Flat Earth community. However, in his case the term Flat Earther is not entirely accurate.

"The thing is, is it flat?" he explains.
"There's a massive question mark about it not being a globe, and we're assuming the alternative is it must be flat — but how do we know it isn't concave, or convex, or hollow? I can't tell you what it is, but I believe I know what it isn't. I'm not a disbeliever of

everything I've ever been given, but I try to look at it with an open mind. Because I'm not a scientist, I've also got to bear in mind that what I come up with may be flawed."

Heather's voice lifts with excitement as he describes the atmosphere at the Flat Earth Convention. Attendees could meet other Flat Earthers for the first time, to discuss theories about what shape the Earth really is, and how and why they feel the truth has been covered up for so long. Heather doesn't have an answer for this, though he thinks it is likely that the scientists themselves have been misled.

He also believes there are question marks over the existence of gravity, the Moon landings, the assassination of JFK

"CONSPIRACY
THEORIES ARE
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CAUGHT PEOPLE'S
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BELOW: Flat
Earthers are not
unique: other
popular conspiracy
theories concern
the assassination
of JFK (top row) and
the Moon landings
(bottom row)









and what really happened on 9/11. I ask him what he thinks about the anti-vaxxer conspiracy theory: the idea that vaccines cause harmful effects such as autism which are being covered up. This is another belief that has been increasingly hitting the headlines in recent years, with a raft of celebrities coming out in support of the movement. Similar to many antivaxxers, Heather expresses a distrust of the people who make these vaccines. "Pharmaceutical companies are out to make, for want of a better word, a fast buck," he says. When I tell him I think it's far more dangerous not to vaccinate your children, he tells me, "I would totally disagree."

Just like the Flat Earth hypothesis and the idea that the Moon landings were faked, the link between vaccinations and autism is completely unsupported by scientific evidence. But conspiracy theorists question the institutions that provide this evidence, and countering their beliefs with logical reasoning doesn't seem to work (see 'Why you can't argue with a conspiracy theorist,' right). Instead, we need to look to psychologists and sociologists to help us understand why these theories exist, and whether they're on the rise. This latter question is a particularly controversial one.





LEFT: Some experts suggest that Flat Earthers (top) and the far right (bottom) are both guilty of the same kind of irrational thinking

WHY YOU CAN'T ARGUE WITH A CONSPIRACY THEORIST

When it comes to challenging deep-seated beliefs, relying on scientific evidence won't cut any ice

RIGHT: Flat Earther Nathan Thompson (right) argues about the planet's shape

BELOW: Nathan Thompson spouts passages from a Flat Earther text







*

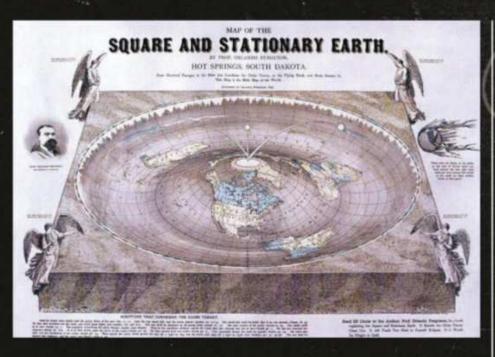
For Dr David Bell, a psychoanalyst and consultant psychiatrist at the Tavistock and Portman NHS Foundation Trust, trying to convince conspiracy theorists that they are wrong is destined to end in failure: "What is demanded is a kind of ultimate proof, which there cannot be." Trying to disprove a conspiracy theory by rational argument will not work, he says, because the premise is not based on rational argument, but on "a very intense emotional need to see the world in this way".

Dr Harry Dyer explains that if you show a conspiracy theorist that science that can prove them wrong, they'll often disregard it, attacking the institution it comes from as being part of the conspiracy. "They don't trust the institutions, and therefore any ideas that come out of those institutions are invalid," he says. "I've never had any success at arguing with people who believe conspiracy theories."

When I spoke to Gary Heather for this piece, he didn't sound crazed or unhinged, as the stereotypical conspiracy theorist is supposed to. In fact, he pointed out that I was the one clinging to my belief that the Earth was round, even though I'd never really questioned the evidence I'd been presented with. I had the impression that, to him, I am blindly following my instinctive assumptions, whereas he sees himself as openminded, taking a scientific approach, and receptive to seeing what the evidence proves. He didn't make me question the shape of the Earth, but he did make me realise that even though we have opposing views on science, our assumptions about each other were very similar.







▶ Dr Rob Brotherton is a psychologist at Goldsmiths, University of London and the author of *Suspicious Minds:* Why We Believe Conspiracy Theories. "People are always saying that this is the golden age of conspiracy theories, that there have never been more than now," he explains, "but the historical perspective suggests that that's maybe not the case."

Dr Michael Wood, a lecturer in psychology at the University of Winchester, says that it has been difficult to measure the change in conspiracy theories over time because earlier surveys took a scattergun approach, asking about different theories and using different wording.

One study that does offer some hints was carried out by political scientists Joseph E Uscinski and Joseph M Parent in 2014. They turned to the letters pages of the *The New York Times* and the *Chicago Tribune* from 1890 to 2010, counting letters to the editor that referred to conspiracy theories. While they found spikes, such as in the 1950s during the 'Red Scare' when fear of communism was at its peak, the authors did not find that conspiracy theories have become more common – in fact, the level has remained fairly consistent.

This is what we would expect to find, says Brotherton: "Believing in conspiracy theories is, at least in part, a psychological phenomenon. Everyone is on a spectrum: some are more inclined to believe and some are less, and it makes sense that this would stay relatively stable over time."

ABOVE: Flat Earther 'Mad' Mike Hughes built a steam-powered rocket so he could go up and see if the Earth is round. In March this year, he managed an altitude of just 570m before deploying his parachutes and landing back on terra firma with a bump. Rocket building ain't that easy, eh?

LEFT: Flat-Earth theories enjoyed a resurgence in the late 19th Century: this map of the world dates from 1893

DEATH OF THE EXPERT?

What *has* changed in the last decade, however, is that the rapid growth of the internet has made it easier for conspiracy theorists to find each other, says Dr Harry Dyer, a lecturer in education at the University of East Anglia. This is what made Heather's convention possible. More than this, social media, Dyer explains, has had a levelling effect, meaning experts have less power than they used to. This was never clearer than when rapper B.o.B tweeted about his belief that the Earth is flat in 2016. His voice was just as powerful as - if not more powerful than - that of Neil deGrasse Tyson, the astrophysicist and head of the Hayden Planetarium in New York City, who tweeted back his own evidence.

Dyer argues: "On social media, everybody gets to have a say and create knowledge. Celebrities like B.o.B can have their say about the shape of the Earth alongside Neil deGrasse Tyson. They both have an equal footing on Twitter, and that means that knowledge has been separated from traditional power structures."

Dyer argues that this trend of toppling scientists from their pedestals is linked to the enormous political upheavals that have taken place in the last few years. Take politician Michael Gove's famous 2016 claim that, "People in this country have had enough of experts," when he was challenged to name economists who supported Brexit. Or consider Donald Trump's presidential aide Kellyanne Conway's coining of the term "alternative facts" in 2017, in order to defend inflated claims of the crowd size at Trump's inauguration. Dyer says that this sort of rhetoric "is being wielded more and more to say: we don't need knowledge, we've got emotions, we've got our gut feelings about the world. It speaks to a general shift away from experts, which can have, as we've seen, quite dramatic effects."

But why would someone be drawn to believing a conspiracy theory when there's so much evidence that points to the contrary? Brotherton says that certain biases in our thinking can help to explain this.

"Our brain has a bias towards seeing meaning rather than just chaos, so sometimes we may think we see a pattern when it doesn't really exist." He explains that this has evolutionary benefits: if a noise in the bushes is believed to be caused by a tiger •

"KNOWLEDGE HAS BEEN SEPARATED FROM TRADITIONAL POWER STRUCTURES"

WHAT MAKES A CONSPIRACY THEORY?

Despite their diversity, there are certain ingredients that many conspiracy theories share



***** SUSPICION

Often there's an official story, and conspiracy theories explicitly push back against it, such as with 9/11. The official story is that this was a terrorist attack, but the conspiracy theory is that it was the government, or someone else. However, conspiracy theories can also emerge as an event unfolds, before the official story becomes clear, in the guise of "there is more to this than we are being told".



DECEPTION

Conspiracy theorists tend to believe that everyone else is being deceived, apart from themselves. The methods of deception, they believe, are elaborate, complex, ongoing and executed almost perfectly - pulling the wool over the eyes of those who haven't yet 'seen the light'.



WICKEDNESS

When real-life scandals are uncovered, we usually find petty self-interest is at the root of it. But in many conspiracy theories, the motivation is apocalyptic and wicked – such as in the case of the 'Pizzagate' conspiracy theory that went viral during the 2016 US presidential election campaign, in which Democrats were accused of running a paedophile ring through pizza restaurants.



SELECTIVE PROOF

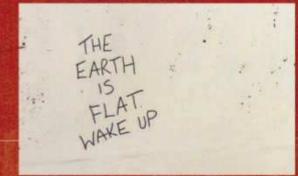
According to some experts, a key characteristic of conspiracy theories is that they have not yet been shown conclusively to be true, but are simultaneously impossible to disprove, as any contradicting evidence is discounted. Take the Flat Earth theory: adherents are still seeking evidence to prove they are right, but no amount of proof showing that we live on a globe can convince them that they are wrong.



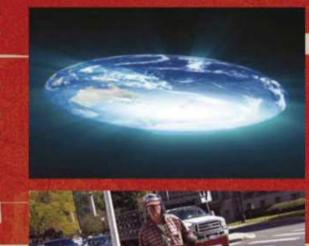
ANOMALY HUNTING

Conspiracy theories are often based not on hard evidence, but on picking holes in the mainstream narrative, pointing out what does not fit or does not seem to have an explanation, and using this as evidence that the conspiracy theory must be true.















rather than the wind, the listener will take evasive action which could save his life. "So when it comes to conspiracy theories, it's all about taking ambiguous information and weaving it all together, spotting the patterns and connecting the dots."

Then there is proportionality bias, where we assume that if something big happens, such as a terrorist attack or a president being assassinated, something big must have caused it. "President Kennedy was assassinated by a lone gunman who no one had ever heard of, which psychologically does not fit with our intuition,' says Brotherton. So a conspiracy theory develops that it was caused by something bigger: the Mafia, the CIA, the Illuminati. A 1979 study demonstrated this effect by showing participants fake newspaper articles with two versions of the same story. In one version, an assassination attempt on a president was successful and the president died; in the other, the president survived. When faced with the bigger outcome (the president dying), participants preferred a conspiratorial explanation; when the outcome was less significant, they believed the story of the lone gunman.

BIASED BRAINS

Conspiracy theories seem shot-through with paranoia, and there is evidence to suggest that the more paranoid someone is, the more they tend to believe these theories. But Brotherton points out that studies show that this is not severe, 'clinical level' paranoia. "It's mundane, everyday suspicions that we all have to some extent — not

Heather appeared on ITV's This Morning.
Presenters Phillip Schofield and Holly Willoughby were unimpressed with his theories

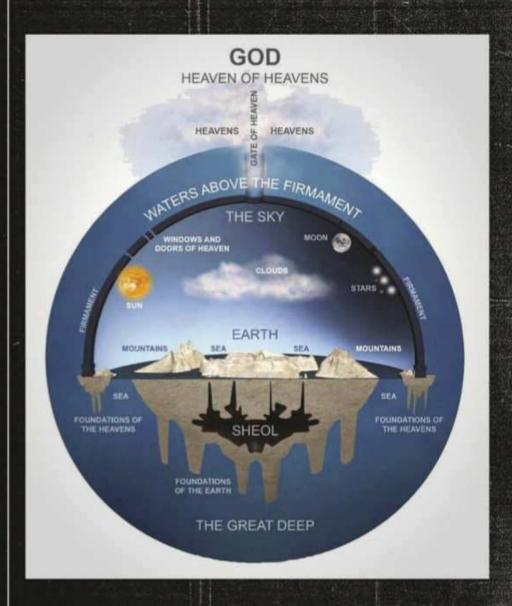
RIGHT: Many Flat Earthers cling to an Old Testament view of the Earth outlandish, tinfoil hat levels of paranoia." Recent studies have also found that people who are more likely to believe in conspiracy theories also tend to have a need for uniqueness—a desire to be in the small group of people who are 'in the know'.

In the grand scheme of things, conspiracy theorists can seem pretty harmless. But there can also be a dangerous side to these theories when they take hold. In July 2018, Public Health England announced that more than 750 cases of measles had been identified across England so far this year, with anyone who had not received two doses of the MMR vaccine at risk – the vaccine at the centre of the anti-vaxxer conspiracy theory. And Dyer believes that the anti-expert, 'follow your gut' rhetoric that fuels conspiracy theories is also helping to fuel the rise of the alt-right and neo-Nazism in Europe and America.

Brotherton is careful to point out, however, that the characteristics linked with conspiratorial thinking are within all of us. "These habits of mind can creep into a lot of beliefs that don't necessarily look like conspiracy theories on the surface," he says. "If you think about a time you didn't get a job you think you deserved, you might find yourself wondering, 'Maybe someone didn't want me to get it'."

Wood agrees: "If a conspiracy theorist is someone who believes in a conspiracy theory, then most of us are conspiracy theorists because most of us believe at least one." So perhaps the most dangerous thing of all is to assume that conspiracy theorists are all other people. •

Moya Sarner is a freelance writer and editor based in London.





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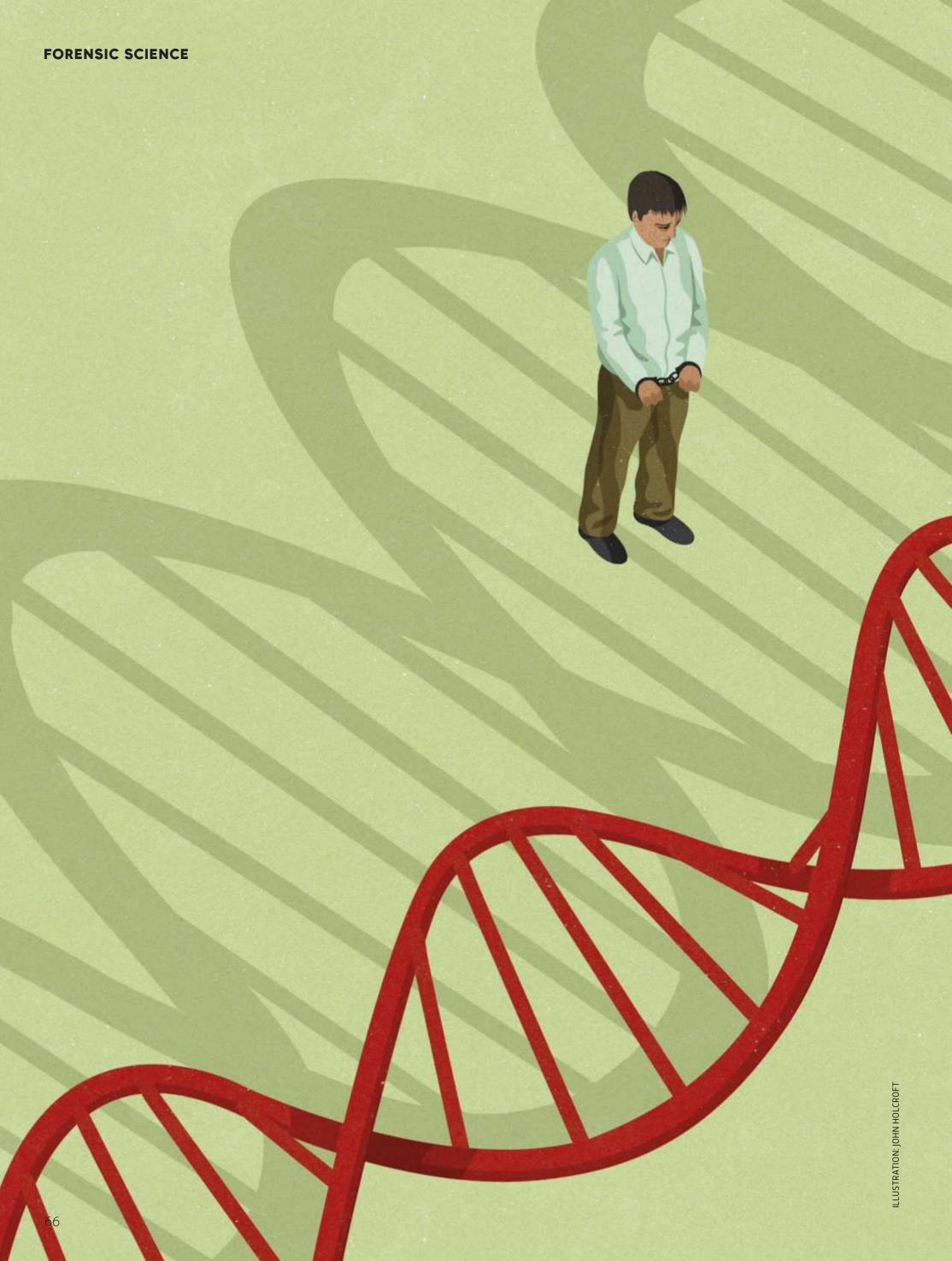
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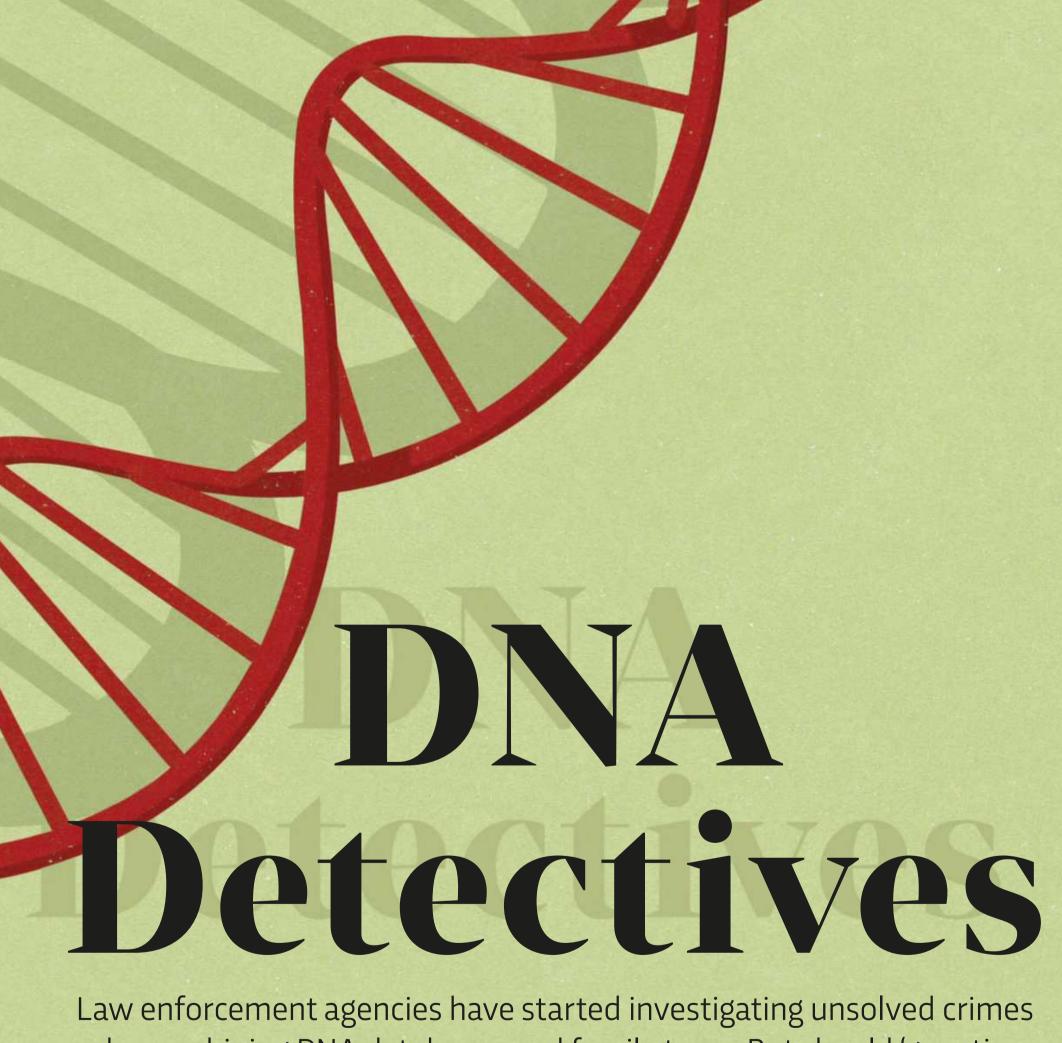
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Law enforcement agencies have started investigating unsolved crimes by combining DNA databases and family trees. But should 'genetic genealogy' really be used to crack cold cases?

WORDS: JV CHAMARY

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rom 1976 to 1986, the residents of California were terrorised by a masked man who raped at least 48 women and murdered a dozen people. His carefully planned attacks suggested military training,

but after three decades, the East Area Rapist – also known as the Golden State Killer – seemed to have got away with his crimes. The case went cold.

Then on 25 April 2018, law enforcement officials announced that they had arrested Joseph DeAngelo, a 72-year-old Navy veteran and former cop. Investigators explained that semen samples from crime scenes had been used to produce the perpetrator's DNA profile and search an online database for potential relatives. The list of matches was then used to build a family tree that led to DeAngelo.

While catching killers using 'genetic genealogy' might sound like an obvious idea, it is by no means straightforward. "Humans are really similar genetically: if I compared my genome to yours, we'd be 99.99 per cent identical," says Prof Graham Coop, a population geneticist at the University of California, Davis. "But there are positions in DNA which are variable between individuals."

TESTING METHODS

Modern genetic tests read the letters of DNA at a selection of positions across the human genome to generate a profile of genetic variants. These single-letter differences represent DNA regions that often vary among people, called 'single nucleotide polymorphisms' or SNPs (pronounced 'snips').

Personal genomics companies like 23andMe and Ancestry offer 'direct-to-consumer' DNA tests that read about 700,000 SNPs. Those variants generate a profile that claim to reveal your family history, ethnic background and susceptibility to disease.

Genealogists who want to study a family tree in detail can upload DNA profiles to a site like GEDmatch, which compares SNPs shared by two people to calculate their genetic similarity. The GEDmatch (GEnealogical Data match) website stores







TOP ROW: Joseph
DeAngelo, the Golden
State Killer, during his
years as a police officer,
and (right) a 1976 police
sketch of the killer

ABOVE: **DeAngelo was** finally arrested in 2<mark>018.</mark> His case is ongoing public profiles uploaded by its one million users. Unlike private databases run by DNA-testing services like 23 and Me, GED match can be searched by anyone who registers for access, which is how investigators found DeAngelo. "Finding these genetic matches is easy," says Coop. "The actual work the investigators did is the hard part."

Catching the alleged Golden State Killer was a

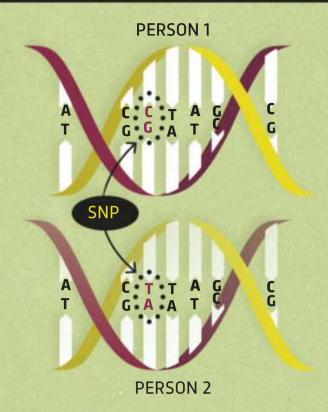
Catching the alleged Golden State Killer was a watershed moment in showing how combining databases and family trees can help crack cold cases. "That really opened up the potential of what we would be able to accomplish," says genetic genealogist CeCe Moore, who previously focused on cases of unknown parentage, like adoption.

Moore now heads the new genetic genealogy unit for Parabon NanoLabs, a firm that provides forensic services to law enforcement agencies. After DeAngelo's arrest, Parabon uploaded more than 100 DNA profiles to GEDmatch, with its permission (investigators didn't ask before uploading the Golden State Killer's profile).

"If police want a DNA sample, they need your consent or a search warrant – at least in principle"

GENETIC VARIANTS

The human genome is our complete set of 23 chromosomes. It's made from DNA and is over three billion letters long. The differences between two individuals are most easily found at locations that commonly vary between us – genetic variants. Here are three different types that are used to compare people

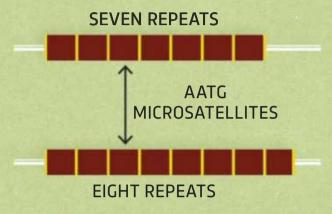


SINGLE NUCLEOTIDE POLYMORPHISMS

Nucleotides, the building blocks of DNA, include one of four chemical letters: A, C, G or T. The most common genetic variations in humans are 'single nucleotide polymorphisms', known as SNPs. These are positions in DNA where two people might carry the same letter, or different letters. There are 10 million SNPs across the genome and the vast majority don't affect how your body works.

Personal genomics firms like 23andMe offer tests

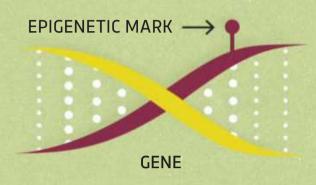
that read SNPs to generate a DNA profile, which is compared against other profiles in their databases to indicate your family history, ethnic background and risk of inherited diseases.



MICROSATELLITES

Approximately 3 per cent of the human genome is composed of microsatellites, also known as 'short tandem repeats' (STRs). Each microsatellite is a repeating unit made up of one to six DNA letters. The number of repeats varies among people. For example, at any given location you might carry a seven copies of the unit AATG, whereas someone else might have a variant with eight copies. The FBI's Combined DNA Index System (CODIS) database has profiles created from 20 positions. Such profiles are also used in forensics and paternity testing, comparing two individuals to

see if they share the same number of repeats at each location.



EPIGENETIC MARKS

While they aren't technically genetic variants, epigenetic marks do contribute to the differences among people. Epigenetic marks are chemical modifications to DNA and its associated proteins that can influence whether genes are switched on or off, and therefore affect the behaviour of our cells. Some marks are attached and removed during the course of development, others are the result of lifestyle choices such as smoking. Scientists can now read where marks highlight sentences on DNA, meaning we could soon take tests that create epigenetic profiles, which could be used in forensics to identify a smoker, for instance. Such personal epigenomic reports might be able to reveal information about your physical features.

Moore's first case was a double murder in Washington State. The male killer's DNA profile was uploaded on a Friday and by Saturday she had a list of matches for building a family tree that led to a marriage that produced three daughters and one son. By Monday, she had a name for the police: William Talbott II.

Parabon now offers a genetic genealogy service to any agency, not just existing customers. With enough human resources, it could help crack hundreds (maybe thousands) of cold cases. If DNA is available, the approach could be applied to other infamous criminals, such as the Zodiac Killer, who murdered at least five people in the late 1970s and taunted police with letters that might carry traces of saliva.

ETHICAL CONCERNS

While it may seem that catching bad guys can only be a good thing, there are legal issues to consider, especially privacy concerns for people whose DNA is stored in a database. What if your profile is downloaded and leads to identity theft? Or genes associated with disease or ethnicity are used to discriminate against you when trying to get a job? Such scenarios could occur in future.

For Americans, the issue centres on whether you're entitled to a reasonable 'expectation of privacy' under the United States Constitution. "One of the biggest privacy protections is the Fourth Amendment, which protects individuals against unreasonable searches and seizures," says Dr Natalie Ram of the University of Baltimore School of Law.

If police want a DNA sample, they need your consent or a search warrant – at least in principle. In practice, they can follow you until you discard DNA in a public place – such as saliva on a coffee cup – then lawfully grab a 'surreptitious sample' (that's how police obtained DeAngelo's DNA). It's possible because you waive your rights to property when it's been thrown away, the 'doctrine of abandonment'. Even uploading your profile to a database might be considered 'abandonment' under US law: in

• the 1970s, the Supreme Court said the Fourth Amendment didn't cover data voluntarily shared with a third party.

What about here? For now, UK law only applies to DNA profiles for convicted criminals. "Our National DNA Database is quite well-regulated in terms of who gets on it, who's allowed to access it," says Prof Carole McCartney of Northumbria University. "But there's no rules about private companies — it will come down to their terms and conditions." The European Union's recent General Data Protection Regulation (GDPR) law gives citizens greater control over how their information is handled, but McCartney thinks it's accepted that the police can use genetic data. British police could search GEDmatch profiles to track down suspects with American relatives.

Over-reach can happen through 'function creep' -

when the use of new technology (like DNA databases) is sneakily stretched beyond its original purpose. This can cause an invasion of privacy, as illustrated by the National DNA Database, which initially added people who had been arrested but didn't remove them after release. The case ended up in the European Court of Human Rights and led to the Protection of Freedoms Act.

The danger is compounded by misplaced trust in the forensic process, which is vulnerable to errors: investigators can cause contamination while collecting DNA, or mix up samples while processing. Despite what's seen on TV police dramas, DNA is rarely featured in trials, which is when experts explain its reliability. "DNA evidence is seen to be so powerful, it's very difficult to defend yourself if you've got your DNA matched," says McCartney. •

RIGHT: DNA testing is helping to catch more criminals than ever, but the wider ramifications need to be considered

HOW IT WORKS

Identifying the perpetrator of a crime using DNA databases and family trees

1. COLLECTING SAMPLES

Crime scene investigators collect biological material such as blood, semen, hair or skin. The DNA molecule decays over time and has a 521-year half-life under ideal conditions (-5°C), but degrades quickly when exposed to heat, light, water and air. Whether DNA stays viable also depends on how well it's stored. The oldest DNA recorded was found in Greenland ice, and was estimated to be between 450,000 and 800,000 years old.

USER

PERP

When someone orders a £100 DNA testing kit from direct-to-consumer genomics companies like 23andMe, Ancestry or MyHeritage, they spit into a collection tube or take cells from a cheek swab, then post the sample to the company. After four to eight weeks, they log into their account for a

report on their genetic variants.

2. TESTING DNA

DNA molecules are cut into fragments and added to a 'genotyping chip'. Genotyping chips are covered in an array of 700,000 microscopic wells, each containing a probe that will match a genetic variant, which may or may not be present in the DNA sample. If a fragment matches, it can be labelled with one of several fluorescent dyes that enables a computer to read each associated DNA letter.

Genomics companies use different genotyping chips, depending what that company believes are the most informative genetic variants. Most companies allow users to download a text file showing their genetic variants or 'genotypes', which are also uploaded to GEDmatch, a searchable genealogy

3. SEARCHING DATABASES

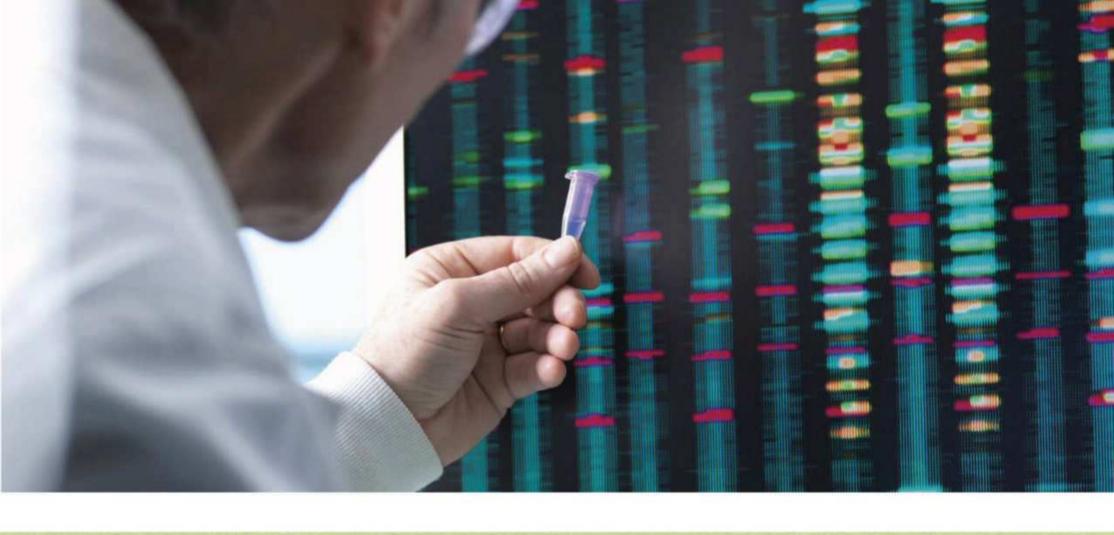
The DNA profile of genotypes for one person, the criminal, is compared against the profiles from other people in GEDmatch's public database. Each genotype is a single DNA letter or 'single nucleotide polymorphism' (SNP) at one of 700,000 positions that vary in the human population. The pattern and number of SNPs shared by any two people is used to calculate their genetic similarity.

A database search is unlikely to return matches with high similarity. As a person inherits half their DNA from each parent, they're 50 per cent similar to their mother and father, 25 per cent to a grandparent. For each generation since cousins last shared a common ancestor, similarity is reduced by a quarter. So first cousins share roughly 12.5 per cent of their DNA, second cousins 3.125 per cent, etc.

Genetic similarity can show if two people are related, but not the relationship between them. You share half your DNA with each parent, as do any siblings, so a 50 per cent match could be mum or dad, sister or brother. Going back to fifth cousins (sharing great-great-great-grandparents) the overlap is just 0.05 per cent – so you're effectively unrelated.

GENETIC

website.



4. BUILDING TREES

The chances of matching many first or second cousins in a database the size of GEDmatch, which contains one million DNA profiles, is extremely low (unless your family's keen on ancestry). But there's a high probability that you'll find tens or even hundreds of third and fourth cousins, as there are enough profiles and their DNA is still similar enough to be identified through genetic similarity.

Genetic genealogists build a family tree by applying traditional techniques to database information, such as the names of two people and their DNA similarity. This includes finding records like census data, newspaper obituaries and birth and marriage certificates, and interviewing living relatives. Nowadays it also involves figuring out relationships via Facebook and other social networks.

Once links between cousins are confirmed, a genetic genealogist works backwards to find where

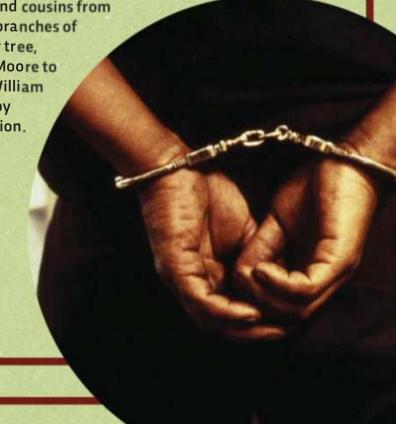
> the separate branches of a tree are connected at their long-dead ancestors. Recent twigs of the family tree - living relatives are then added by building forwards, what expert CeCe Registration Acts Moore calls 'reverse genealogy', which can sometimes succeed in 'triangulation' - when two distant branches intermarry.

5. FINDING SUSPECTS

Police, FBI and other law enforcement agencies use conventional investigative methods before arresting a suspect. For the Golden State Killer, investigators only had a list of third cousins (sharing great-great-grandparents and under 1 per cent genetic similarity) so they had to use an extensive process of elimination (the offender was about 5'9" and 75kg, for example) to narrow it down to Joseph DeAngelo.

Identifying a suspect requires putting all the pieces of a puzzle together. In Moore's first genetic genealogy case, GEDmatch had a list of possible relatives that included two distinct matches, each with a 3 per cent similarity to the

killer's DNA. This suggested they were second cousins from different branches of the family tree, enabling Moore to identify William Talbott II by triangulation.



GENEALOGY



with a picture of his then 19-year-old son. Usry Jr was vilified online as a murderer due to partial DNA evidence, but was later found innocent

hide, you may still be asking yourself the question: where's the harm in using my DNA to help catch a killer? The answer depends on your personal ethics and how you weigh the benefits for victims against potential costs to other people.

One key issue is informed consent. "I'm really not confident that people understand or are even aware that their genetic genealogy can be used for criminal or forensic purposes," says Dr Benjamin Berkman, a bioethicist at the US National Institutes of Health. Until recently, he adds, information about such disclosures was 'buried in the small print'.

Berkman says the problem stems from expectations. People signed up to GEDmatch to study their family history, not aid law enforcement. And although the site's original terms of service did warn users that DNA profiles could be used to help identify related to victims or criminals, some members didn't realise that until DeAngelo's arrest hit the headlines, then felt so misled that they deleted their accounts. GEDmatch has since revised its terms to explicitly

"In contrast to the criminal justice system, in the media you're often guilty until proven innocent"

of a violent crime.

Informed consent also means being conscious of the impact 'familial searching' could have on others. "I like to think about it in terms of your cousin getting arrested," explains Berkman. "Some would say 'The fact that my DNA indirectly helped to lead him to justice, it's fine', but you can imagine other people who would feel guilt or conflict about having caused a relative to go to jail."

FALSE POSITIVES

When someone is under suspicion for a crime, their name can get leaked to the press – and in contrast to the criminal justice system, in the media you're often guilty until proven innocent. That's what happened to US film-maker Michael Usry Jr, who was investigated in 2014 for a 1996 murder, based on a partial match to his father's DNA following a familial search of a database (the FBI even secured a warrant for cheek swabs). Even if you're later cleared, as Usry was, being branded a killer could still haunt you for the rest of your life.

"At the end of the day it's your genome," Berkman concludes. "And if you want to learn more about your ancestry or your genealogy or your health, I don't know that other people get to tell you what you can and can't do with your DNA."

But for genetic genealogist CeCe Moore, the ethical balance tips toward the victims of crime and their families. "These families have often been waiting for decades for justice and some sort of closure," she says. "And we are finally able to provide that through this new technology and techniques."

JV Chamary is a writer with a PhD in molecular evolution and genetics. He covers science and technology for Forbes.com

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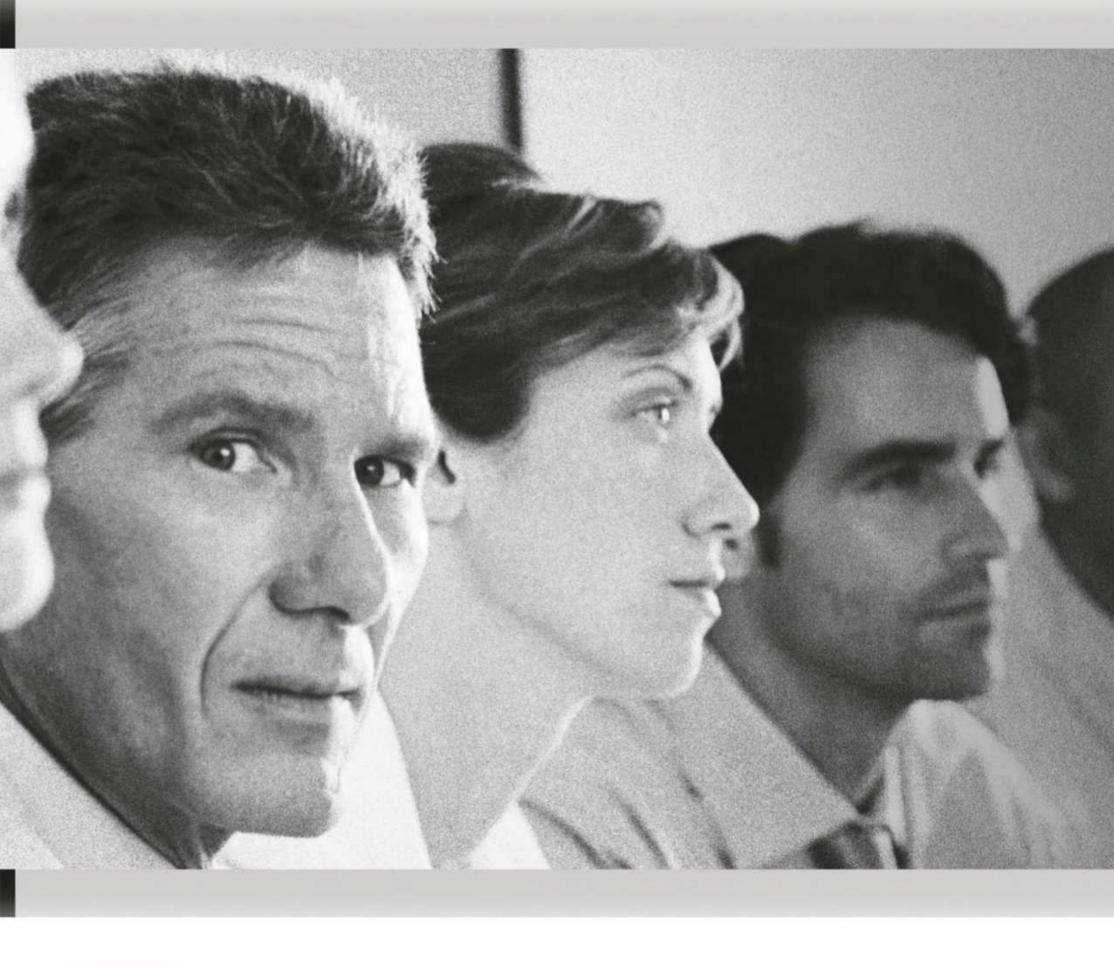


THE PSYCHOPATHS AMONG US

Despite what Hollywood suggests, psychopaths aren't easy to recognise due to their habit of accessorising with a blood-soaked axe and a maniacal leer. So how can you spot them, should you be worried, and could you be working alongside one right now?

WORDS: DR NICOLA DAVIES





hillingly cool, collected, cunning and clever. Is this the perfect description of a psychopath? For most people, Hollywood movies and popular culture generate such images of psychopathy. Be it Anthony Hopkins as Dr Hannibal Lecter in *The Silence Of The Lambs* or *Psycho*'s Norman Bates, such characters dominate the public's perception of a psychopath. But how close is this popular image to reality?

The term 'psychopath' originated in the 1800s, from the Greek words 'psykhe' and 'pathos', which mean 'sick mind' or 'suffering soul', respectively. However, this can be misleading.

"Psychopaths might be better conceptualised as people who are dissociated," says criminologist Robert Blakey. "In other words, people who are detached from their own emotions and the emotions of other people. Consequently, they just don't feel much. If they see a person in distress, psychopaths don't feel

the distress themselves, so they have less emotional incentive not to harm people."

Blakey believes this dissociation can arise from inheriting an over-sensitive perceptual system. "If you're very sensitive to visible signs of distress and anger in other people, then seeing those signs could become overwhelming for highly sensitive children," he says. "A deficit in one's ability to predict other people's behaviour as a child can be a traumatic experience and, in response, the child's brain may dissociate." In other words, the empathy system shuts down to survive the emotions of others. The irony here is that people born with an excessive capacity to empathise could be more likely to develop psychopathic traits due to losing their full capacity for empathy in their efforts at self-preservation.

This has parallels with a similar theory about autism which, like psychopathy, is a disorder of social cognition. While autism is typically considered a deficit in cognitive empathy,

"MOST PSYCHOPATHS HAVE TRAITS THAT BLEND INTO THE FABRIC OF OUR LIVES!"

• or perspective taking, psychopathy is a deficit in emotional empathy. While the relationship between autism and psychopathy has gained increasing interest due to the shared lack of empathy, research indicates many distinctions between the two conditions. The most relevant distinction is that individuals with autism are not amoral, unlike psychopaths.

BORN TO BE VILE?

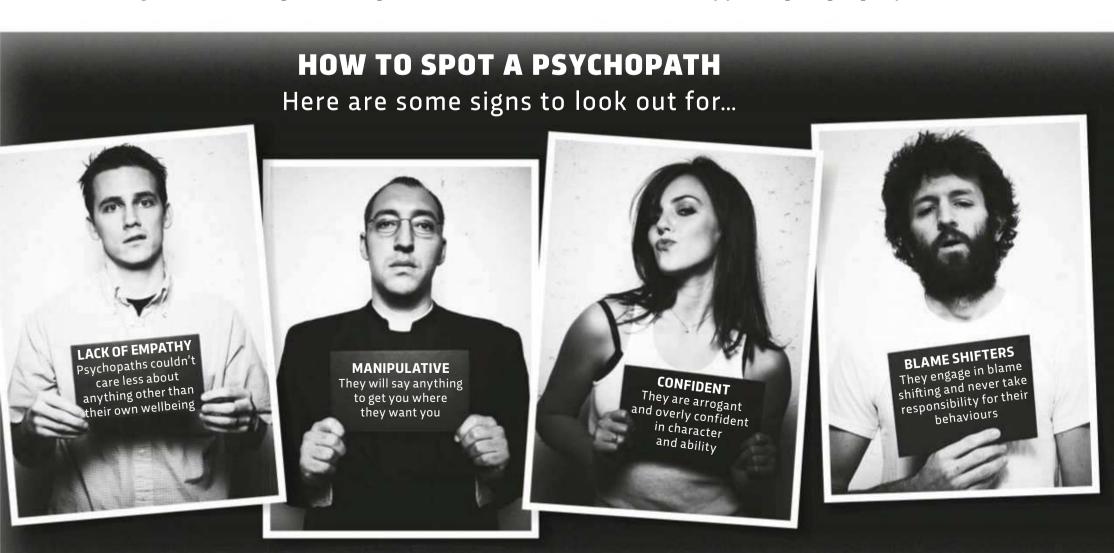
One way to identify a psychopath is to study patterns in their relationships. Psychopaths generally cannot sustain long-term relationships, so short periods of intensity followed by detachment tend to define their close interactions. While in a relationship, their behaviour is likely to be highly manipulative and selfish, with their needs always coming first.

Not all psychopaths are violent criminals, but most present a threat to our welfare at some level — to one's self-esteem, peace of mind, sexual health or financial wellbeing. There are many theories behind why psychopaths are the way they are. Some believe it is nature, or genetics, that causes psychopathy. Others think it is related to environmental factors. Whatever the cause, medically speaking people with psychopathic tendencies demonstrate certain traits.

Researchers from Harvard University investigating decision-making in psychopaths took magnetic resonance imaging (MRI) brain scans of 50 prison inmates, with the aim of investigating the choices that psychopaths make. They found that people with signs of psychopathy had brains that were wired so that they over-valued immediate or short-term rewards. This desire for instant gratification overshadowed any concern about the consequences of their actions.

They also found that people who scored highly on the parameters of psychopathy — as assessed by a delayed gratification test, an estimation model, and the Psychopathy Checklist (PCL-R) — showed greater activity in the brain's ventral striatum. This is a key part of the reward system. In another study of 164 chimpanzees carried out at the University of Georgia, researchers found that a neuropeptide called vasopressin is associated with the development of socioemotional behaviours related to psychopathic personalities. This adds further support to a genetic element in the development of psychopathic traits.

Environmentally, the impact of socialisation in a child's early years is perhaps equally influential in the



formation of psychopathic behaviour. And according to Claudio Vieira, a clinical psychologist based at King's College, London, many different personality disorders – including psychopathic personalities – may result from a combination of genetic elements that shape our personalities, life experiences, and socioeconomic circumstances.

Psychopathic characteristics also vary by culture. A US and Netherlands study comprising over 7,000 criminals exhibiting psychopathic traits revealed that US-based offenders tended to predominantly display the psychopathic trait of callousness, while the Dutch offenders showed greater evidence of irresponsibility. These traits were measured using the PCL-R, which might be interpreted differently in different cultures. Nevertheless, the research raises some interesting areas for further study.

A TOUGH CALL TO MAKE

Be it nature or nurture, the popular image of a psychopath is largely influenced by the ambiguity surrounding its definition and diagnosis. Ironically, psychopathy is not actually an official diagnosis. In the *Diagnostic And Statistical Manual Of Mental Disorders* (DSM-5) — the official criteria used to classify mental disorders in the US — the closest condition to psychopathy is Antisocial Personality Disorder (APD).

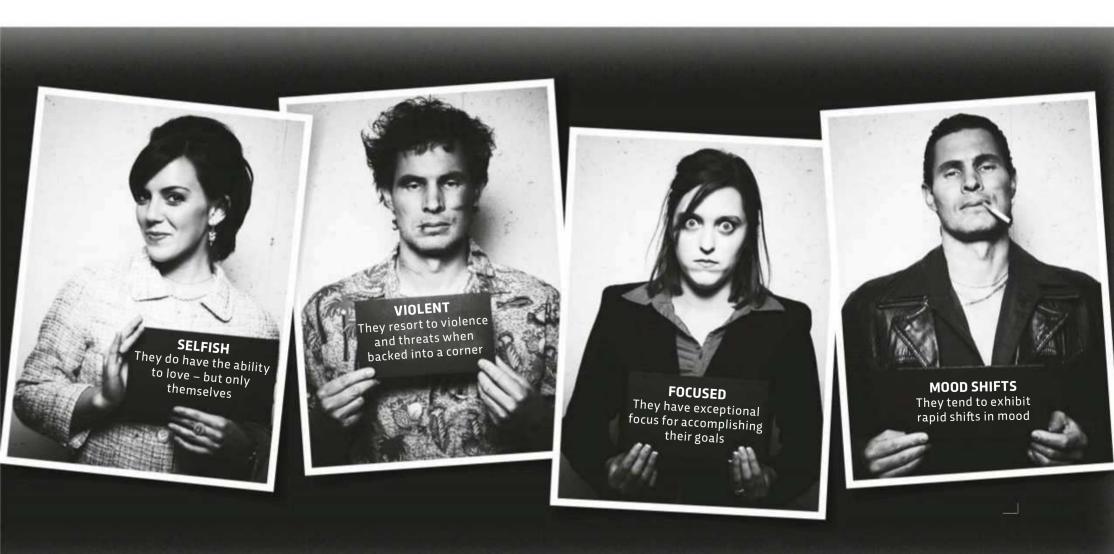
"APD is characterised by impairments in personality functioning and by the presence of pathological personality traits. However, while offenders with psychopathy often have APD, offenders with APD are not necessarily psychopaths," explains Vieira.

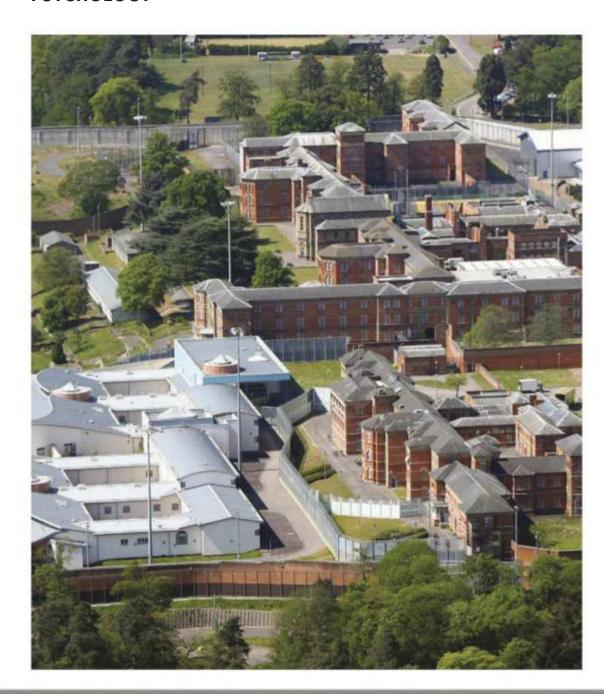
The closest thing to a checklist for identifying a psychopath is the PCL-R mentioned earlier. This comprises a list of 20 character traits and behaviours NORMAL

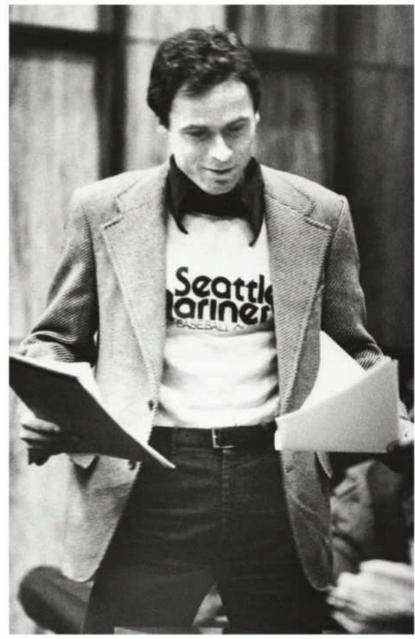
PSYCHOPATH

ABOVE RIGHT: In the scan of the normal brain, there is activity in the frontal lobe (marked with an arrow), which is associated with emotional response; in the psychopath brain, there is little activity in this region

- such as a lack of remorse or guilt, failure to accept responsibility, shallow emotional response and having many short-term relationships – to help determine if an individual is on the psychopathy spectrum. However, such a checklist does not serve as a 'one size fits all' formula for diagnosis. On the contrary, psychopathic traits can be hidden or subtle. In addition, the chances are that you know people who display some of these traits – that's because the majority of people have psychopathic tendencies. In most people they may be situation-specific or low level, but psychopathic traits certainly aren't restricted to the full-blown psychopath. ●







CAN PSYCHOPATHS BE TREATED?

There's no cure, but research suggests psychopathy can be made more manageable – if caught early enough

The traditional consensus among psychiatrists and psychologists has been that psychopathy is an untreatable condition. Even respected mental health professionals have bandied around terms like 'just evil' to describe psychopathic criminals. But while there's certainly no sign of a cure on the horizon, in recent years some evidence has emerged to suggest that young psychopaths, in particular, can at least be taught to manage their condition.

In 2001, a study carried out by Michael Caldwell and Gregory Van Rybroek at the Mendota Juvenile Treatment Center in Wisconsin, USA, found that young offenders diagnosed with psychopathic traits were far less likely to reoffend if given 'decompression therapy'. This involves moving slowly from a punitive model of care to one of positive reinforcement, in which youths were rewarded for more 'normal' behaviour. Since then, this treatment is said to have reduced rates of reoffending by a third.

More recently in 2012, David Bernstein, a professor of forensic psychotherapy at the University of Maastricht, began using an approach that he calls 'schema therapy', which focuses on encouraging patients to reaccess the emotional and empathetic responses he believes have often, in psychopaths, become 'locked away' due to trauma or abuse during childhood. It's still early days for a treatment of this kind, but the initial results are promising, suggesting that offenders with psychopathic tendencies are less likely to reoffend if they've undergone schema therapy. And unlike decompression therapy, schema therapy seems to work for adults as well as for young offenders.



LEFT: Ted Bundy fooled many people with his charm and charisma. Yet he was a violent serial killer who felt no guilt or remorse for his crimes – a classic psychopath

FAR LEFT:
Broadmoor Hospital
is a high-security
psychiatric hospital
that has housed a
number of notorious
patients, including
Peter Sutcliffe,
Ronnie Kray and
Charles Bronson

RIGHT: Some mental health professionals have claimed that Donald Trump could be a psychopath • "Most people with psychopathic traits blend beautifully into the fabric of our everyday lives," explains Dr Paul Hokemeyer, a clinical and consulting psychotherapist based in New York.

MURDEROUS MINORITY

The lack of a diagnostic tool or a presence in the DSM-5, is partly due to the mystery surrounding psychopathic behaviour. This has led to the predominantly inaccurate media image of a psychopath.

"The nature of cinematic and literary depictions is that they overdramatise the traits found among psychopaths by having them brutally murder a slew of victims," says Hokemeyer. "Top of this list include Javier Bardem's character in *No Country For Old Men* and Christian Bale in *American Psycho*. In real life, however, psychopaths seldom murder outright."

Prof Samuel Leistedt and Dr Paul Linkowski, forensic psychiatrists based in Brussels, investigated the history of the cinema-psychopathy relationship in 2014 by analysing 400 films and shortlisting 126 fictional psychopathic characters on the scales of realism and clinical accuracy. They found that psychopaths were often caricatured as sexually depraved and emotionally unstable, with sadistic personalities and eccentric characteristics. Such images aren't necessarily realistic; indeed, Leistedt and Linkowski believe that certain cinematic psychopaths such as Norman Bates in *Psycho* and Travis Bickle in *Taxi Driver* are psychotics rather than psychopaths.

While psychopathy is a personality disorder underlined by callousness, recklessness, impulsive behaviour, lying and lack of empathy, psychosis refers to a mental state where the person has lost touch with reality. Psychopathy is typically not associated with any loss in the sense of reality: individuals know where they are and what they are doing. The perception that 'psychotic' and 'psychopathic' are one and the same simply isn't the case. While the former is an outward display of a chaotic personality, the latter is more internal, and difficult to spot. Far from being the crazed, damaged individuals portrayed in the movies, there is mounting evidence that many people with psychopathic characteristics are highly successful. "Psychopaths are very good at seeing which behaviours a system rewards and exhibiting those behaviours. This is one route to career success," says Blakev.

It is not surprising, then, that a 2016 Australian study found that around one in five US corporate leaders displayed psychopathic traits. Psychopaths may be poor at managerial tasks, but they are often adept at climbing the ladder by hiding weaknesses and charming their colleagues. Another potential benefit, according to Blakey, is that the typical psychopath doesn't care about other people's feelings and therefore they don't feel the same compulsion to protect them from negative emotions. As such, psychopaths find it

easy to embark on emotional risks that other people might hesitate to take.

So while at extreme levels psychopathy can lead to antisocial and destructive behaviours, at moderate levels it can offer some advantages. The key difference is between 'clinical' and 'functional' psychopaths. Functional psychopaths know in which context to exhibit their characteristics. When it comes to goals, psychopaths have laser focus, persistent ambition, self-confidence and social charm. According to Hokemeyer, this functional aspect of psychopathy could be the real risk to society.

"The most dangerous trait of psychopaths is their ability to operate in stealth. On the surface, they can appear to be warm, genuine and incredibly charismatic," he says. "But just below the surface of their veneer lies a mountain lion waiting to pounce."

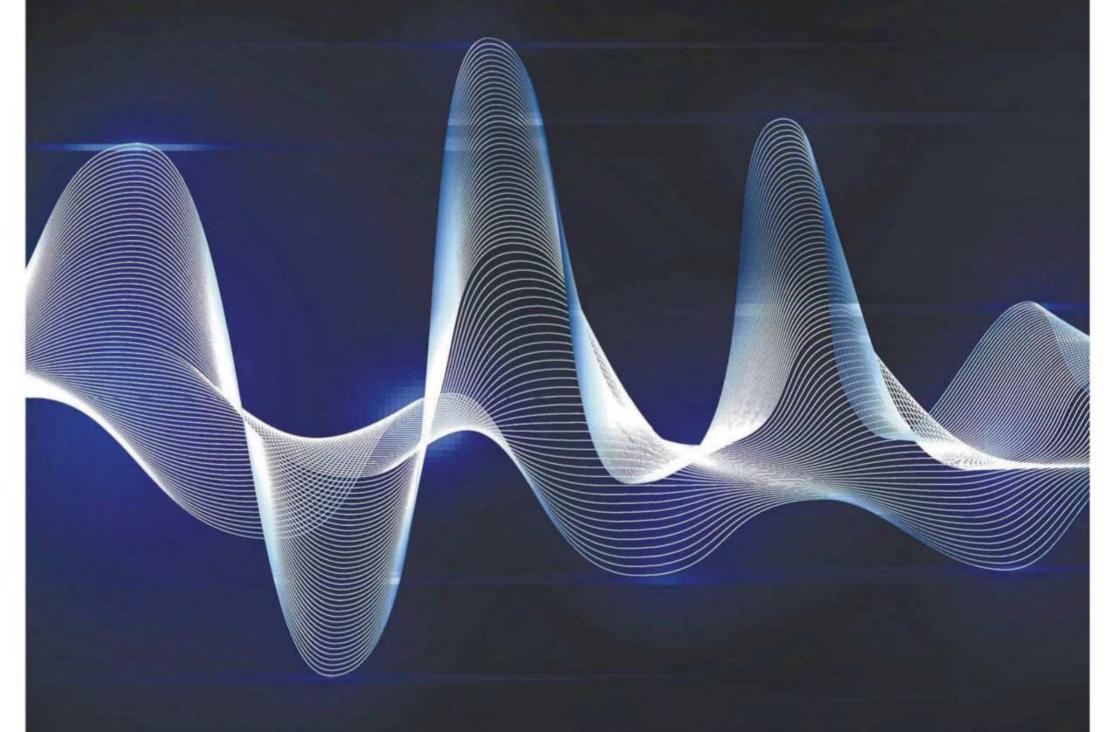
Beyond the Hannibal Lecters of the cinema, the story of the psychopath remains somewhat of an enigma. Scientists know more about psychopathy today, based on case studies and brain research. Yet there is still much we don't know, and the knowledge we do now have is unsettling to many: psychopaths are not necessarily evil but regular human beings with a 'twist' – traits that make them adept at getting their own way. And they live among us every day.



Dr Nicola Davies is a medical writer and consultant health psychologist.

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DAVIES Chemistry expert,



VILLAZON

writer

Science/tech

DR GILES YEO Geneticist, food expert



science writer

QUESTIONS ANSWER

EDITED BY JAMES LLOYD SEPTEMBER 2018





16-20,000

Age, in years, of prehistoric arrowheads unearthed in Gault, Texas. This means humans had made their way into North America at least 2,500 years earlier than was previously believed.

1,400°

The temperature that heat shields on NASA's Parker Solar Probe will need to withstand. Although temperatures in the corona reach millions of degrees, there's very little matter there, so the actual heating effect is quite low.



Does the body need salt?

PHOEBE YATES, GRANTHAM

We can't survive without it. It's crucial for our nervous system to function, our muscles to contract and relax, and for maintaining fluid balance.

However, the amount that we need is actually very small: less than a quarter of a teaspoon a day. Almost all of us consume more than that, and exceeding 6g (a teaspoon) per day could be harmful if you're at risk of, or have, high blood pressure. The best way of reducing salt intake is to eat less processed food. **zw**

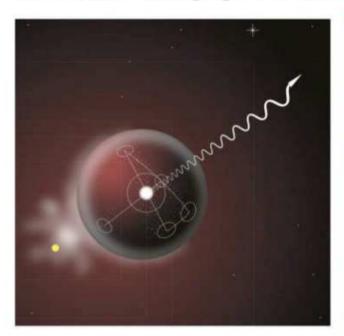
Does the Sun make a sound?

SIMON PRICE, ABERDEEN

The Sun does indeed generate sound, in the form of pressure waves. These are produced by huge pockets of hot gas that rise from deep within the Sun, travelling at hundreds of thousands of miles per hour to eventually break through the solar surface. As a result, the Sun's atmosphere is seething like a pan of boiling water. The characteristics of sound waves, such as their speed and amplitude, depend on the material they pass through, so they can be used to study the Sun's deep interior. Unfortunately, though, the wavelength of these waves is measured in hundreds of miles, and so they're far outside the range of human hearing. AGu

THE THOUGHT EXPERIMENT

WHAT WOULD HAPPEN IF ALIENS CONTACTED US?



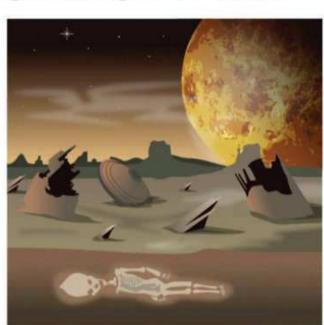
1. COULD WE DECODE IT?

Humans have only been transmitting radio signals for around 80 years, and already we are phasing out analogue transmission systems such as AM and FM in favour of digital signals. These are much easier to detect – but only if you know the encoding system. Without this key piece of information, any transmission from an alien civilisation would just sound like background static.



2. COULD WE UNDERSTAND IT?

In 1974, the Arecibo telescope broadcast a 23 x 73 pixel image at the M13 star cluster. Although it contains details of our counting system, DNA structure and place in the Solar System, it's so cryptic that even other humans probably wouldn't be able to decipher it. An alien message might have such an abstract set of priorities and assumptions that we would never understand what they were trying to tell us.



3. ARE THEY STILL THERE?

Even if we received and understood a message, its senders would probably be long gone. A 2018 study at the University of California, Santa Cruz, found that if civilisations last fewer than 100,000 years, the odds of detecting a signal while the transmitting civilisation still exists are almost nil. So there's not much hope of sending (or receiving) a reply.



Why do football players spit so much?

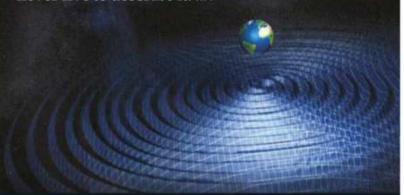
JOHN FARRUGIA, QORMI, MALTA

Several studies have shown that exercise increases the amount of protein secreted into the saliva, especially a kind of mucus called MUC5B. This mucus makes the saliva thicker, which makes it harder to swallow, so we spit it out. It isn't clear why we produce more MUC5B when exercising, but it may be because we breathe through our mouth more, so the mucus stops the mouth from drying out. Some sports, such as basketball and tennis, penalise players for spitting, but football and rugby don't, so the players are free to expectorate! LV

What would happen if a very strong gravitational wave passed through us?

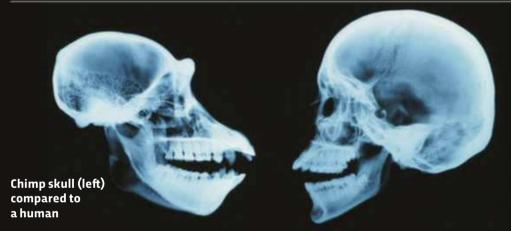
THOMAS S MARCOTTE, USA

Gravitational waves spread out from any violent event involving matter – such as, say, the collision of two black holes. Like gravity, however, they're incredibly weak, so you'd have to be extremely close to their source in order to feel their effects. It would definitely feel weird, as they'd create a rhythmic stretching and squashing sensation on the body. But you'd have to be so close to the cataclysm itself that you'd never live to describe it. RM



Is it possible for humans and chimpanzees to interbreed?

PAULINE HETHERINGTON, SURREY



Genetic analysis suggests there may have been a long period of crossbreeding between early ancestors of the humans and chimpanzees, before they finally split into the *Homo* and *Pan* (chimp) genera around six million years ago. But today, although humans and chimpanzees share 99 per cent of the DNA sequences that code for proteins, that DNA is packaged differently into the chromosomes. The human chromosome number two is actually two ape chromosomes joined end-to-end, and nine other chromosomes have inverted sequences of genes compared with their equivalents in chimps. Humans and chimps also have differences in their individual genes that are far bigger than the differences between any two unrelated humans.

These are big obstacles, but not necessarily insurmountable. Other animals with comparable genetic differences, such as zebras and horses, have bred successfully in the past, although the offspring are almost always sterile. There are documented cases of Soviet experiments in the 1920s where artificial insemination was attempted using female chimps and human sperm. However, none of these experiments resulted in a pregnancy, much less the birth of a 'humanzee'. There are various urban legends of other later experiments in different labs worldwide, but there's no evidence that the result was ever any different. LV

Is the Japanese practice of wearing face masks effective in reducing the spread of colds?

EDWARD SEYMOUR, HOVE



The wearing of face masks has become the norm in Japan, even making it as far as the couture catwalks. But what many people in the West don't realise is that they're usually worn by a person who has the cold or flu to protect others, rather than to protect the wearer. This is also true of the face masks worn by dentists and surgeons, which are designed to stop the wearer spreading their germs to the patient.

However, by providing a barrier, the masks are also effective at protecting the wearer from airborne viruses. They likely add further protection by keeping the mucous membranes in the nose and throat moist, helping our airways to expel germs, and they've also been shown to protect hav fever sufferers from pollen. **zw**

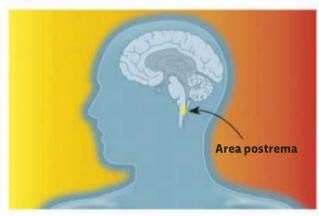


WHAT HAPPENS IN MY BODY WHEN...

...I'm seasick

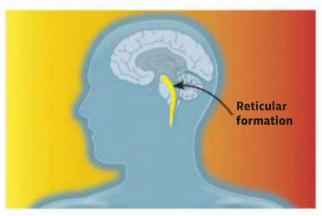
KEVIN MORTON, CHATHAM

One theory suggests that seasickness occurs when the motion we feel with our inner ear doesn't match the motion we see. The brain mistakes this for a hallucination caused by poisoning, and we vomit as a defensive measure. Recent studies also suggest that side-to-side motion is much more nauseating than purely up-and-down movement.



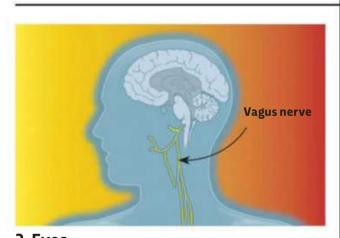
1. Brain

The 'area postrema' is a part of the brain that detects chemical toxins, and triggers vomiting to get rid of them.



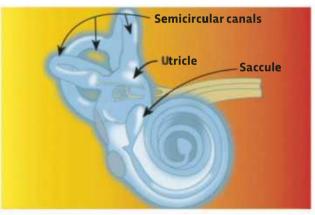
2. Brainstem

The 'reticular formation' group of neuron clusters regulates arousal. Seasickness is often accompanied by drowsiness, perhaps because the wave motion mimics the rocking that soothed us as infants.



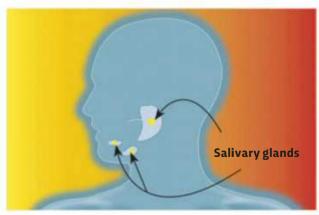
3. Eyes

The eye muscles stretch as you automatically try to compensate for the motion. This may stimulate the vagus nerve, which can also trigger vomiting.



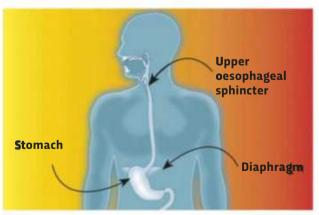
4. Inner ear

Conflicting signals from the utricle and saccule (otolith structures) that detect linear acceleration, and the semicircular canals that detect rotational acceleration, are another possible cause of nausea.



5. Mouth

In preparation for vomiting, the salivary glands produce extra saliva. This protects the mouth and throat from being burned by stomach acids.



6. Stomach

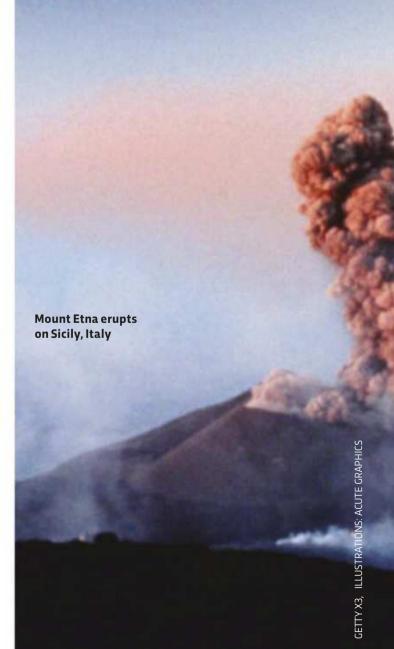
Sustained and powerful contractions of the diaphragm and abdominal muscles pressurise the stomach. When the upper oesophageal sphincter is released, the stomach contents spews out.

If all radioactive elements decay, why are there still radioactive elements on Earth after billions of years?

PAUL LOWE, MANCHESTER

Every time a volcano erupts, it's a reminder we live on a seething cauldron of natural radioactive elements. The principal source of geothermal heat is the radioactive decay of isotopes of uranium, thorium and potassium, all of which have been present in the Earth since its formation around 4.5 billion years ago. The reason they're still so potent is that their atoms are disintegrating at a slow rate.

This is measured by their socalled half-life: the time needed for their activity to fall by 50 per cent. All three of the main sources of radioactivity in the Earth – U-238, Th-232 and K-40 – have half-lives similar to the age of our planet, and so are still going strong. RM







Is autism found in any other animals?

PETER, FAKENHAM

Autism is a neurodevelopment condition found in humans, and some of the diagnostic criteria, such as a delay in language development, can't apply in a straightforward way to animals. That said, some animals do display autistic-like traits, such as a tendency toward repetitive behaviour or atypical social habits. Bull terriers, for example, are especially prone to repetitive tail chasing, which some experts liken to the spinning that is sometimes seen in children with autism. $\mathbf{c}_{\mathbf{j}}$



How is a sponge able to hold so much water?

PAUL, VIA SCIENCEFOCUS.COM

Natural sponges are simple marine animals that don't have any organs. Instead, they rely on their huge surface area to absorb oxygen and nutrients and to get rid of waste products. The flexible skeleton of these sponges (or the plastic equivalent in a synthetic sponge) holds water because the complex labyrinth of dead ends and narrow channels slows the water as it tries to drain away. Squeezing the sponge compresses the channels and the extra pressure helps to force the water out more quickly. LV



WHO REALLY DISCOVERED?

NUCLEAR FISSION?





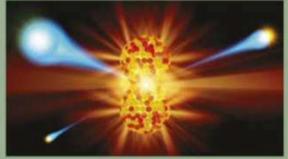
OTTO HAHN

LISE MEITNER

After millennia of exploiting sources of chemical energy, such as wood, the discovery of nuclear fission in the 1930s gave humanity access to something far more potent: energy released by the splitting – 'fission' – of atomic nuclei. Immediately recognised as the basis of a weapon of mass destruction, and now used to generate around 10 per cent of the world's electricity, nuclear fission has always been controversial. Even its discovery provokes arguments.

What's not in doubt is that nuclear fission was first achieved by a team led by the German chemist Otto Hahn in 1938. Along with his colleague Fritz Strassmann, Hahn found that uranium atoms could be split by bombarding them with neutrons. But baffled that mere subatomic particles could achieve this feat, Hahn contacted Lise Meitner, a former colleague and physicist based in Sweden. Together with fellow physicist Otto Frisch, she showed how fission really worked, and even gave the process its name.

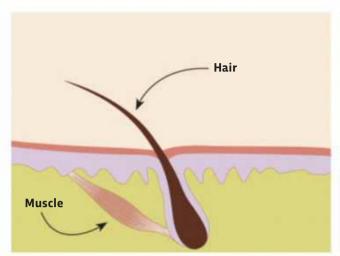
Yet in 1944, the Nobel Committee awarded its chemistry prize solely to Hahn, ignoring the crucial insights of Meitner and Frisch. Historians now believe that, at the very least, Meitner should be regarded as the co-discoverer of nuclear fission, and suspect her contribution was overlooked in part because of her gender. RM

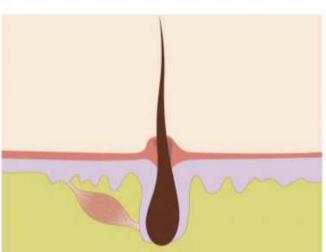


Nuclear fission involves splitting atoms into smaller parts, and releases a lot of energy

Why do our hairs stand on end when we're cold?

TOBY GRAHAM, SHREWSBURY





When we're chilly, tiny muscles contract at the base of each hair to make them stand on end, distorting the skin to create goosebumps. All mammals share this hair-raising trait, called piloerection, of using hair or fur to trap an insulating air layer. The process may have helped to keep our hairy ancestors warm, but today's human body hair is too fine to be of much use. Shivering does a far better job of warming us up through rapid muscle contractions. **ED**



Is there any evidence-based therapy or rehabilitation for someone said to be 'evil', such as a serial killer?

GAVIN ANSELL, STAFFORDSHIRE

Serial killers and other offenders dubbed 'evil' by the public and media usually meet the criteria for what forensic psychologists call 'psychopathy'. Cool and calculating, these individuals combine superficial charm with callousness and a lack of empathy.

Traditionally, this group was seen as being nigh-on impossible to treat.
However, this pessimistic perspective was recently labelled an 'urban myth' by psychologists in New Zealand, and there

is limited evidence that intensive group and individual therapy programmes, based around the principles of cognitive behavioural therapy (CBT), can help reduce violent offending by psychopaths, if not change their personalities *per se*.

Another promising, but preliminary, line of research suggests that computer-based cognitive training can help psychopaths experience empathy and regret. For more on psychopathy, turn to p74. c

WHAT IS THIS?



seen here are the fertilised eggs of a female sea snail of the genus Janthina. Measuring just a few centimetres across, these snails are pelagic, spending their entire lives in the open ocean.

They emit a substance called chitin, which traps bubbles of air, and these bubbles join together to form 'rafts' on the water's surface, below which the snail will float. Different species of janthinid snail incubate their fertilised eggs differently: in some species they're ejected from the female's body in a casing that attaches to the female's raft, but in Janthina janthina they develop within her body.



IS FASTING GOOD FOR YOU?

We teamed up with the folks behind BBC World Service's *CrowdScience* to answer your questions on one topic. You can tune in to *CrowdScience* every Friday evening on BBC World Service, or catch up online at **bbcworldservice.com/crowdscience**

What happens in our bodies when we fast?

Food provides the cells in our bodies with their fuel: glucose. Our bodies release a certain amount of glucose into the blood and store the rest as glycogen, releasing it as needed. Once that supply is used up – after at least 12 hours without food – our fat stores are called upon.

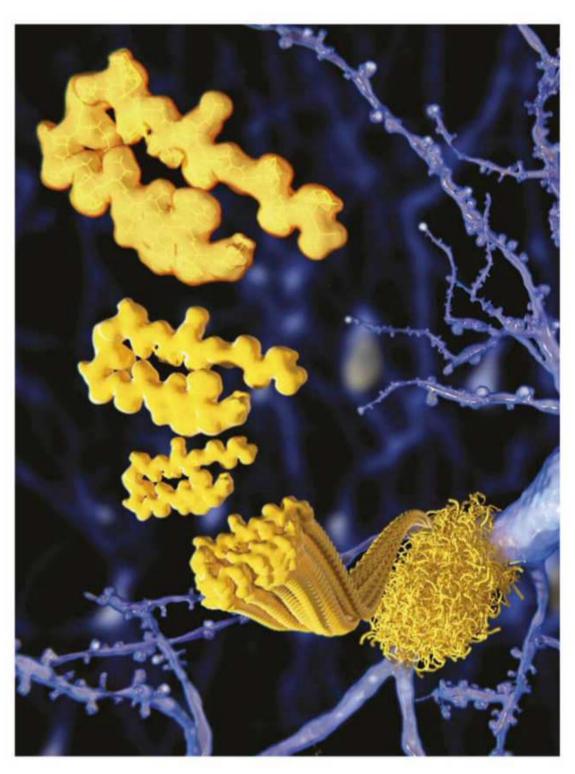
Burning fats rather than glucose produces substances called ketones, and high levels of these can suppress hunger (which may explain why many fasters claim to be less hungry after several days of fasting). Researchers are looking at the effects of this metabolic state on the body. For instance, research dietician Dr Michelle Harvie at the University of Manchester has found that, by dampening down levels of certain hormones, fasting could help reduce the risk of breast cancer.

Is fasting an effective way to lose weight?

Fasting forces the body to start burning fat. So on a basic level, restricting your food intake can be an effective weight loss technique – but scientists are divided on which approach gives dieters the most health benefits. Intermittent fasting, such as the '5:2 diet', recommends two consecutive, low-carbohydrate, 500-800 calorie days to safely lose weight.

However, you need longer periods (three to four days without carbohydrates) to put your body into ketosis, the state where your appetite will start to decrease. Experts don't recommend trying this without medical backing, cautioning that the long-term consequences of high-intensity fasting are not fully understood.





Are there any other unexpected health benefits to fasting?

Fasting seems to benefit the mind. Neuroscientist Dr Mark Mattson has shown that mice on calorie-restricted diets are sharper than their better-fed friends when it comes to memory tests, and in 2016, his work with humans suggested that fasting could help protect the brain from the amyloid proteins that build up during Alzheimer's disease. Meanwhile, Prof Tim Spector at King's College London has noticed that fasting also affects our gut bacteria: several species of bacteria found in people with good health appear in higher levels after a fast. So occasionally skipping breakfast might be enough of a fast to benefit your microbiome.

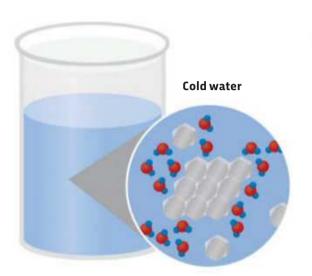


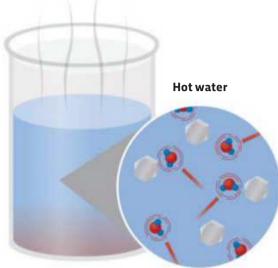
Marnie Chesterton is the presenter of *Is Fasting Healthy?* an episode of *CrowdScience*. It can be streamed at **bit.ly/crowd_science_fasting**

Why is hot water a better solvent than cold water?

MICHELLE DU BOIS, PORTLAND, OREGON, USA

In hot water, molecules are moving around more, so there are more collisions between the water molecules and a solid





A solvent is a substance that can dissolve other substances — water is a good solvent. Dissolving a solid requires energy input to disrupt the forces holding the molecules together, both in the solid and the water. Most solids, including sugar and salt, become more soluble with increasing temperature. This is because heat increases molecular movement, causing more collisions between the water molecules and the solid. But the opposite is true for gases, which tend to become less soluble as a solvent's temperature increases. As the gas molecules become more active, they can break free from the liquid, which explains why drinks soon lose their carbon dioxide fizz on a hot day. **ED**



How often should you wash your bath towels?

LISA PERRY, STIVES

Damp towels do breed bacteria, but it's important to understand that we are constantly surrounded by bacteria on virtually everything we touch. The bacteria on your towel nearly all originally came from your skin, and if you aren't sick and don't have any open cuts or wounds, there's no reason to suppose that transferring some of these germs to a towel and then back to you will make them any more dangerous. The American Cleaning Institute recommends washing towels every three or four uses. But surveys show that most people reuse them at least five times, apparently without any serious consequences. LV

QUESTION OF THE MONTH

Do two mirrors facing each other produce infinite reflections?

SAL SMYTHERS, CAMBRIDGE

It's always fun to look at the multiple reflections formed by opposing mirrors in lifts, washrooms and the like. But while they seem to extend into the infinite, in reality they get progressively darker and fade into invisibility long before they get there. That's because mirrors absorb a small fraction of the energy of the light striking them each time. Thus even the best mirrors are unlikely to generate more than a few hundred visible reflections. RM



Email your questions to questions@sciencefocus.com or submit online at sciencefocus.com/qanda

OUT THERE

WHAT WE CAN'T WAIT TO DO THIS MONTH

SEPTEMBER 2018 EDITED BY HELEN GLENNY



LEAVE THE LIGHT BEHIND

Dive down to the ocean's gloomy depths and you'll find an array of fascinating creatures, one of which might be this giant deep sea isopod. Growing to a length of 76cm, they look like huge underwater woodlice, one of their distant relatives. You can find them skimming the seafloor 2,000m below the ocean's surface, or for an easier viewing, catch them in the Natural History Museum's exhibition *Life In The Dark*.

Life In The Dark illuminates the buzzing ecosystems that exist in the darkest caves and the deepest oceans, and reveals the extraordinary diversity of animals that thrive in a world without light. Immersive installations recreate environments that are off-limits to most humans, with many usually inaccessible species on display to the general public for the first time.

"At any one time, half the world is in darkness – and no sunlight ever reaches the deep sea or underground caves," said Prof Geoff Boxshall, science lead on the exhibition. "Yet the night-time world is teeming with life, and both the deep sea and caves are inhabited by a myriad of species. Even in the absence of light, life has found a way."







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BRITISH SCIENCE FESTIVAL

HULL AND HUMBERSIDE 11-14 SEPTEMBER BRITISHSCIENCEFES-TIVAL.ORG

CELEBRATE BRITISH SCIENCE

This September, Hull and the surrounding Humberside area will transform into a large-scale celebration of science, as the University of Hull hosts the British Science Festival. We talked to the festival director IVVET MODINOU about creating one of Europe's biggest science events

How did the British Science Festival come about?

There's been an annual meeting of scientists since the beginning of the British Science Association in 1831. Sometime in the 1990s we started calling it a festival, but the idea has stayed the same: it's about trying to bring current researchers together to share their work with whoever's interested. It's hosted somewhere different every year.

How do you decide what topics to cover at the festival?

It's extremely broad. In the programme you'll see things about space, volcanoes, archaeology and psychology, but we also include things like music, the arts and exercise. We really try to cover the whole spectrum.

It's not just lectures, right? There are some really unique events going on...

We work with our host organisation, the University of Hull, to create a variety of formats and engagement styles that suit their research best. Tired of listening to lectures? Engross yourself in these unusual events instead



HOWL AT THE MOON

Artist Luke Jerram has hung a seven-metre model of the Moon in Hull Minster, and on 11 September, for one night only, you can sing along to space-themed tunes with the University of Hull Chapel Choir.



DISTORTIONS IN SPACE-TIME

Experience what it's like to step into a black hole in this brand new immersive artwork. You'll be turned into particle clouds on a giant screen, then squashed and stretched by gravitational waves.



ATTRACTION EXPLAINED

On 12 September, psychologist Viren Swami will discuss how geography, appearance and personality affect who we fall for and why. Then you can test out your new knowledge on someone you get paired with on the night...



CSI OF THE SEA

If a cetacean dies after becoming beached on UK shores, ideally a postmortem will take place. The Deep, Hull's Aquarium, is opening for free on 12 September, when you can look around and witness a cetacean dissection in progress.

Take UV Yoga, for example. Kat Sanders, a University of Hull anatomist, will be taking people through a yoga class in the dark, where the instructor is covered in UV paint that highlights the muscles she uses in different poses. It's a fun way to share that new anatomy research.

Do current events influence the talks?

Definitely. Each year we have the Huxley debate, where we pay homage to the famous debate about evolution between Thomas Henry Huxley and Bishop Samuel Wilberforce. That happened at the 1860 festival, seven months after Darwin's On The Origin Of Species was published. It was an opportunity for people to have a conversation about the boundaries of science and what we don't know, in front of an audience, as science is often seen as something that happens behind locked doors. Each year we take a topic where the fringes are still being discussed – this year it's

about plastics. We've also got talks about Brexit, AI and the ethics around technology.

What events are you most looking forward to?

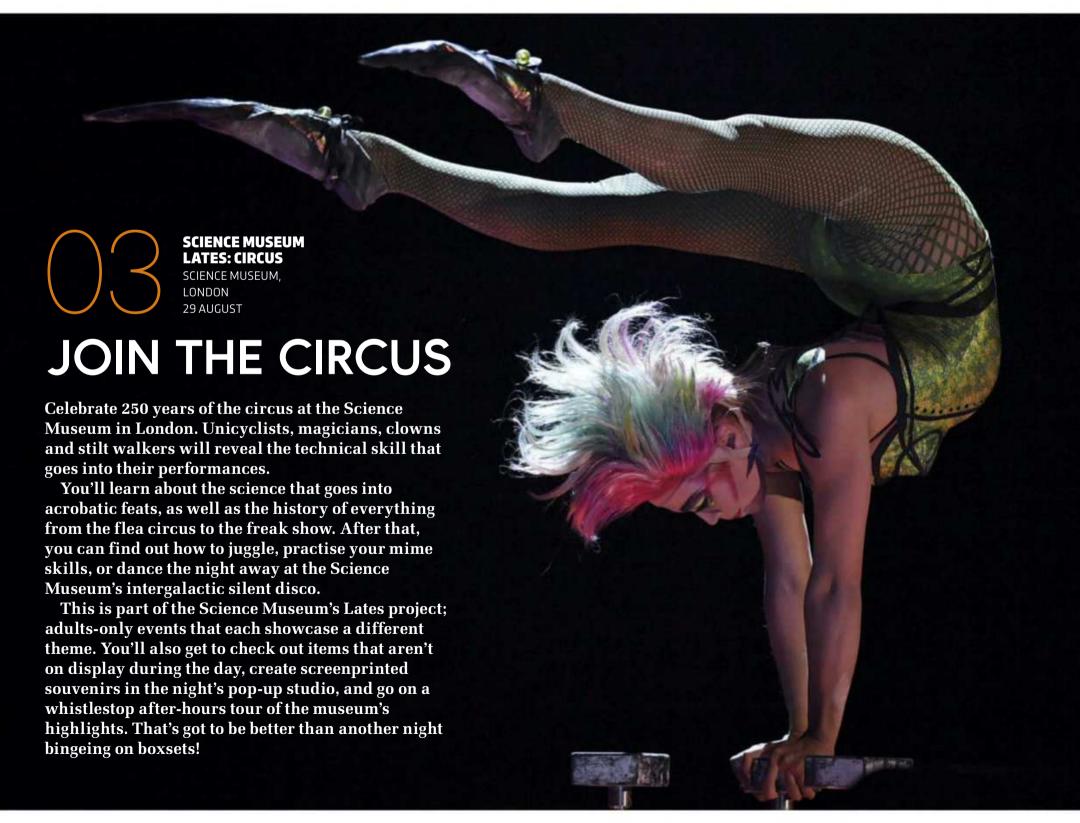
I'm looking forward to seeing four-time UK champion beatboxer Grace Savage talk to a researcher about why beatboxing is so unique.

We also have a great event with Lemn Sissay, the poet, in conversation with Jocelyn Bell Burnell, who will be talking about how physics influences the poetry she writes.

The festival is free to attend. Was that important for your team?

Yes, we've tried to get rid of one of the barriers that exist around getting people to attend science events. We also know that you might come along to a science event because you really love physics and space, but you might stay for something completely different – you're more likely to do that if it's free.

LEFT: Two visitors tune in to the Tree-Listening Project, by Alex Metcalf





THE STORY
OF S***
BY MIDAS DEKKERS
OUT 30 AUGUST
(£12.99, TEXT PUBLISHING)



RETHINK POO

MIDAS DEKKERS has taken a deep dive into the history of our bowels in his new book, *The Story of S****. Here are five reasons why he thinks we should be more positive about poo



A poo is bursting with life, like a reef full of fish or a rainforest full of monkeys. In every gram of faeces there are more than a billion living bacteria. As long as it stays inside, they'll divide a couple of times an hour.

2. POOING CAN HELP US SURVIVE

The need to defecate when in danger is part of the 'fight or flight' reflex – an antelope s***s its brains out at the sight of an oncoming lion. An antelope poo may not weigh much, but it can mean the difference between life and death if the animal can run a little faster without it.

3. IT HELPS US LOCATE ANIMALS

Researchers looking for eagle droppings are assisted by the sunburst lichen that grows on them. With its bright colours, this lichen makes it possible to see from great distances where the eagles foul their home rocks in the Arctic. Similarly, in 2012 a new colony of emperor penguins consisting of 9,000 individuals was found in Antarctica in the Princess Ragnhild Coast area. The animals gave themselves away by their excrement, which stood out clearly on the satellite images as brown against the white sea ice.

4. WE CAN USE POO TO MEASURE TEMPERATURE

A turd reflects the temperature of the body's inner sanctum. That's actually the normal method for taking an elephant's temperature, for instance, because inserting a thermometer into a fresh elephant dropping is much easier than trying to insert it into one of the animal's bodily orifices.

5. POO IS A GREAT SOURCE OF NUTRIENTS

Until the rapid urbanisation of the 21st Century, more than 90 per cent of all the human faeces in China ended up in the fields. The prestige of human manure reached a high point during the country's Cultural Revolution. According to Mao Zedong, your turd did not belong to you but to your entire commune.

TOTAL DARKNESS FREE, OUT NOW TOTALDARKNESS. SCIENCEMUSEUM.ORG.UK

PLUNGE INTO DARKNESS



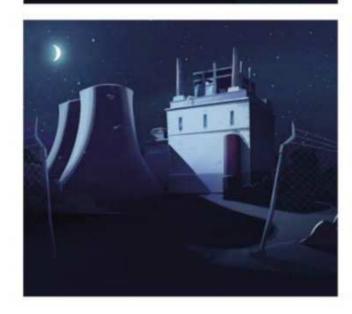
The power's gone out in your town.
There's no Wi-Fi, there's no television,
and you can't finishing cooking your
microwave popcorn. What do you do?
Get out there and investigate, of course!

The Science Museum Group has recently released *Total Darkness*, a computer game aimed at youngsters aged 7 to 13. Each player has to navigate dark streets, form theories and solve problems – all before their torch runs out of battery.

The player's choices score them points for creativity, curiosity and communication. At the end of the game, the player will learn their 'science style' and how they can put their skills into action in the real world.

By gamifying science, Susan Raikes, director of learning at the Science Museum, hopes to get children interested in science outside school hours. "We hope that by playing the game, more people will see that science is a subject that goes beyond the classroom – it's part of our everyday lives and something everyone can do and be a part of."



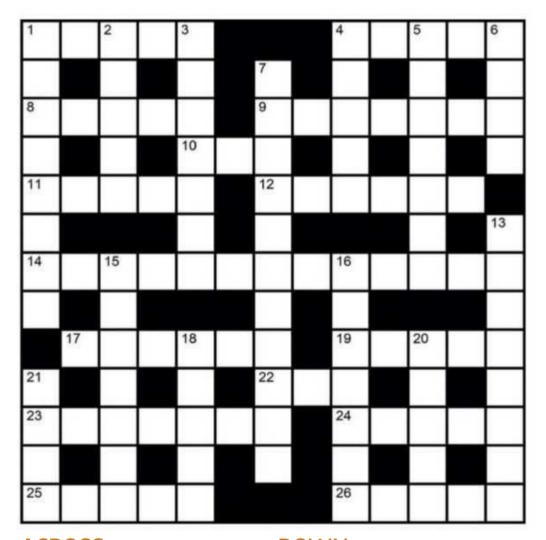






BBC FOCUS CROSSWORD

GIVE YOUR BRAIN A WORKOUT



ACROSS

- 101 back again after five concerning city (5)
- 4 Vandalism has no time for a shoe (5)
- 8 Drive one politician to the Spanish (5)
- **9** A friend finds ancient city incompetent (7)
- **10** Pass out of recollection (3)
- 11 Firm rig wrecked by dog (5)
- Native American has about a year to turn to Georgia (6)
- 14 My sets claimed to work in base 10 (7,6)
- 17 Reporting delay is important (6)
- 19 Primate to rule out getting married (5)
- 22 Gamble without diamonds to get diamonds (3)
- Spoil new coat, having played with emphasis (7)
- 24 Insult didn't start trivial (5)
- 25 Brainbox loses current category (5)
- **26** German and Italian one outside a waste (5)

DOWN

- Incorporated one cipher, enveloping tally to occur at once (8)
- 2 Bigwig joins queen, the snake (5)
- 3 Still taking copper with iodine and another element (7)
- 4 Flaking like an anteater (5)
- The growth of ale drinking? (4,3)
- **6** Correct or terribly wrong inside (4)
- 7 Reckoning to call auction off (11)
- A horse race getting round to a liqueur (8)
- 15 Caught bird wearing V stripe (7)
- You will audibly record Christmas fare (4,3)
- **18** Good girl has some wine (5)
- 21 Let up and come about phone lines (7)
- **20** Graduates take head of geography to be hot stuff (5)
- 21 Second cat creates pollution (4)

ANSWERS

For the answers, visit **bit.ly/BBCFocusCW**Please be aware the website address is case-sensitive.

NEXT MONTH IN

FOCUS

How we'll leave Earth

THE INNOVATIONS THAT'LL ENABLE US TO LIVE IN SPACE



PLUS

Don't worry, eat curry

Let's talk: male suicide

Women in science















Ella Al-Shamahi

Did you hear the one about the anthropologist who walked into a comedy club? **Ella Al-Shamahi** talks to **Helen Pilcher** about combining stand-up with fossil hunting

Ella's dream dinner party: Jesus, Muhammad, Buddha, Desmond Tutu, Nelson Mandela, Ellen DeGeneres, Oprah Winfrey and Jennifer Aniston.

What do you do?

Too much. I'm a stand-up comedian, I do bits of TV and I'm also a PhD student studying Neanderthals. I go into unstable, hostile and disputed territories to look for Palaeolithic caves. I go to the

places the government advises you not to visit. The sorts of places you can't get insurance for. I've worked in Syria and in the Yemen.

Why are you drawn to conflict zones?

Partly because these places are underexplored, and partly because fossils can help to create a narrative of hope. Fossils can be a source of national pride, and can draw tourists and resources.
Because they transcend political divisions, they can act as a rallying point uniting people to help rebuild places post-conflict.

Do you think Neanderthals had a sense of humour?

It's hard to say. I've watched non-human primates that seem to have a sense of fun, so I think it's reasonable to imagine
Neanderthals did too. There are different kinds of humour — stand-up is a European

"YOU WOULDN'T HAVE SEEN A NEANDERTHAL AT THE BACK OF THE CAVE DROPPING THE MICROPHONE"

and American concept. You wouldn't have seen a Neanderthal at the back of the cave dropping the microphone.

What inspires your stand-up comedy?

There are a lot of dark narratives in my life. My family is from the Middle East. My work takes me into conflict zones. So it's really important to me to find the funny in life. I've no interest in just making you laugh. I really want to make you laugh and think.

What has surprised you over the course of your career?

The level of neocolonialism and racist undertones among certain people who work in the academic, adventure and media space. It's been a real shock. It's directed at the people and the places in which I work. I'm confused as to why this still exists.

Best experience of your career?

Going on a scouting mission to Socotra, an island between mainland Yemen and Somalia. It's been described both as the most alien-looking place on Earth and as the Galápagos of the Indian Ocean. We sailed across the Indian Ocean for three days on a cement cargo ship that was infested with so many cockroaches it seemed like the floor was moving.

Are you working on anything exciting at the moment?

I've just done an episode of *Horizon*. It's about circadian rhythms. We put an adventurer in an underground bunker and messed up his sleep for 10 days to see what happened. It's a really big deal for me to have *Horizon* under my belt. Little girls from Birmingham don't usually get to do this sort of thing. •

Ella Al-Shamahi is a PhD student at University College London. Look out for her in an upcoming *Horizon* episode about circadian rhythms on BBC Two.

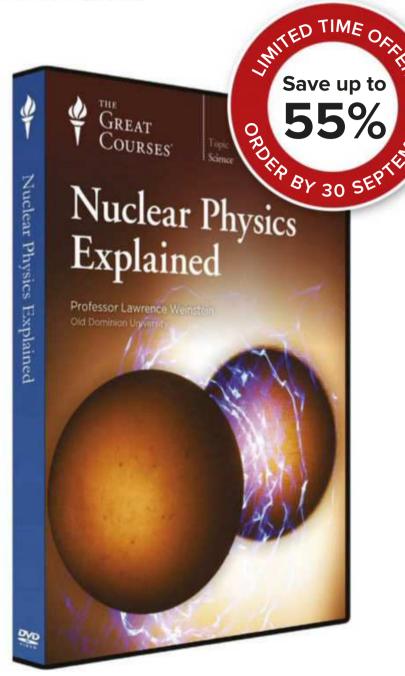
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NEXT ISSUE: DR DAVID SALTZBERG





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- 5. How Dangerous Is Radiation?
- 6. The Liquid-Drop Model of the Nucleus
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- 13. Nuclear Fusion in Our Sun
- 14. Making Elements: Big Bang to Neutron Stars
- 15. Splitting the Nucleus
- 16. Nuclear Weapons Were Never "Atomic" Bombs
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